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THE SCIENTIFIC MONTHLY

FEBRUARY, 1919

SCIENCE AND THE AFTER-WAR PERIOD[1]

By Dr. GEORGE K. BURGESS

BUREAU OF STANDARDS

SOMEWHAT more than a year ago it was my privilege to address the Philosophical Society of Washington on the subject, "Science and Warfare in France,"[2] in which I endeavored to indicate in some small measure the rôle science was playing in the war we all hope has just been brought to a close.

At this time may we not consider the transition period into which we are entering and ask ourselves what will be the effect of war on science, the men of science, and in the relations of science to the community and the state? What are some of the lessons this war has taught? And what plans have been made here and elsewhere to apply them?

A scientific man would hardly be so rash as to pose as a prophet, yet he may nevertheless try and assemble and pass in review some of the tendencies of the time; and it is only by an intelligent examination of the underlying changes which are being produced in science and in its relation to society that he is enabled to see his way ahead a little more clearly into the mist of the future; and he may thereby be enabled, at least in some small degree, to chart his course and take advantage of the various currents that have been set in motion by the war.

The question may here be asked, can we not see from previous wars what this war will bring forth, or at least the broad lines along which progress will be made, in science and in its relation to mankind? But with what previous war shall we compare this? Surely not with the short Franco-German war of 1870 in which but two nations were engaged; and if with the world-wide wars of the French revolution and Napoleon

[1] Address of the President of the Philosophical Society of Washington, January 4, 1919.

[2] SCIENTIFIC MONTHLY, October, 1917.

we have a duration of twenty-five years as compared with four; and if any war prior to that epoch is considered the development of science was hardly in a state to form a basis of comparison.

Again you may be asked, does war, did this war, stimulate scientific progress? Viewing the wealth of application of science in modern warfare, you will probably unhesitatingly say "Yes," but if you undertake to make a list of fundamental, new scientific principles developed as a war reaction I believe you will be embarrassed to name even a few of them, although there have been, of course, hundreds, nay, thousands, of applications of known scientific principles to new uses. It is still too soon, however, to estimate the scientific advance during the war and as caused by the war and such, even though I were competent, is not my purpose here. It will evidently be impossible to treat adequately the subject of "Science and the After-War Period" except in a most summary manner and I shall have to limit myself to certain phases in which I have been interested, paying particular attention to the physical sciences and the relation of science to industry.

What is the effect of the war on scientific production, is not an easy question to answer. Many men have been killed, including a few who are scientific producers, and many more young men who might have become distinguished in science; furthermore, not a few scientific centers have been destroyed. Thus viewed, there would appear to be a net loss to science in the world, but at the same time there have been stimulated to greater endeavor a considerable number of men of scientific ability and many new laboratories established. I believe that, for the United States, the effect of the war will not be detrimental to scientific production, as our losses in young men of scientific attainments have been relatively insignificant, and also I firmly trust the country has in part learned the lesson of the advantage to the nation of generously supporting research.

For a country such as France, which has borne the brunt of the fighting for four years, and not until after the first battle of the Marne was any effort made to conserve her scientific men, the matter appears to be much more serious; but who dares to predict that the United States, with nearly three times her population, will lead France as a producer of original ideas in science a generation hence? It is well to remember that many of the master minds in science of the nineteenth century were born during the Napoleonic wars, and that it is quality and not quantity that counts in scientific progress.

Finally one may ask, is the after-war period to be one of great scientific activity or one of relative quiet, and what will be the lines along which development will take place? This brings us to a consideration of the nature and permanence of war activities in science. Never before have science and scientific men been used to such an extent, both relatively and absolutely, as the servants of war both in the military establishments proper and in the not less important industrial supports. It is evident that what is beneficial in these relations should be maintained. In addition to the advancement in scientific knowledge, much of which is not yet generally available, brought into being by the war there has also been worked out for war purposes, in a more or less satisfactory way, schemes of cooperation of scientific men with each other, with the state, with industry and with the military. Some of these are transitory in character, others are serviceable for both peace and war, and some have been devised especially for the after-war period.

One might perhaps expect a certain relaxation of effort, even among scientific workers, following the strenuous efforts of the war, but one must not forget the natural zest of the scientific man to get back to his chosen field, which he will want to cultivate in his own way and not under the more or less arbitrarily imposed conditions of military requirements. Although much of the scientific work of the war has been done individually, probably by far the greater part has been by collective efforts of groups of workers usually under the guidance of some responsible committee or executive. Although this is no new phenomenon in scientific research, yet this cooperative method of attacking difficult problems has been, under the stress of war, developed to a hitherto unheard of degree. It is probable that the naturally individualistic traits of scientific men will tend to cause a lessening of this type of common endeavor, although in the distribution of investigation, between groups or individuals, there will probably be a greater number of groups than before the war, the habit of working together having been fostered, and its advantages appreciated in certain cases. For scientific research carried out in the interest of industry, this group method will very likely be greatly developed.

One of the fundamental factors of the greatest economic importance, which the exigencies of the war have brought repeatedly to the fore both in battle and in workshop, is what one might almost call the crusade of standardization. This has

taken on innumerable aspects and has constantly been recurring in conservation programs, economic production, and in the elimination of waste, time, materials and men. The savings that may be accomplished by the scientific application of what we may call the principles of standardization in production, manufacture and distribution of many, if not most, of the more usual commodities of commerce and industry is so great that I believe that it is not an exaggeration to say that by this means alone our national debt could soon be paid off both interest and principal. An indication of what can be done along this line has been ably demonstrated in our own country by the War Industries Board and in particular its Conservation Division working in cooperation with the various industries.

This cooperation between government and industry has been made most effective by the enforced revival of the guild organization in industry; the fact that an industry has been represented successfully as a whole during the war by an elected committee in treating with the government and among themselves on matters of common interest, is charged with great possibilities for like action along voluntary lines during peace times. Although of course many of the questions thus treated may be considered as outside the realms of science, nevertheless the scientific men can not be separated from this development which, it is most urgently desired, may be continued, although along less arbitrary lines than were necessary in time of war.

A closely related matter is that of preparing satisfactory specifications for materials and manufactured articles. Washington might almost have been called a specification factory during the past eighteen months. This is economically one of the most important of subjects, and too great emphasis can not be given to the desirability, not merely for materials of military interest, but for all uses, of being able to define adequately and sufficiently—not too loosely nor yet too rigorously—the materials and articles that form the basis for practically all purchases. There has been and still is in many fields great confusion, uncertainty and differences of opinion as to facts, and most of this is, in the last analysis, a direct result of ignorance of the scientific data regarding properties and materials on which the specifications are based. The nation has undoubtedly suffered untold losses on account of this ignorance, and endeavors should be made on a sufficiently comprehensive scale to eliminate as much as possible the waste arising from this cause.

Innumerable instances could be cited of the harmful and costly effects of too rigid specifications and of course we all know some of the dangers of too loosely drawn specifications. I will cite two of the former in my own field of metallurgy—a foreign government had a limitation, dating some thirty years back, of 0.05 per cent. copper in a certain grade of munition steel being made here. All the steel made from certain ores in this country necessarily carried four or five times the stipulated copper. Although at first insisting on the rejecting of the steel, the government in question finally accepted it after overwhelming evidence was submitted showing that ten times the amount of copper was not detrimental merely but of actual advantage in this steel. This single contract involved several millions of dollars; the total cost of all the experimental work ever done the world over on the effect of copper on steel would be at most a few thousands.

The second illustration is given by another government which desired to purchase steel here for aircraft parts with a phosphorus and sulphur content together of less than 0.03 per cent. They could buy no steel, and if they had been able to place an order it would have been at an exorbitant price. The fact that all the other allied countries were using a much less rigid specification with safety finally convinced them that theirs was too severe. Incidentally this latter case shows the evident advantages of interchange of ideas and experience in such matters.

Not a little of the delays in production of many materials for war purposes was due to the multiplicity of specifications insisted upon by the various independent purchasing departments of the government. Some progress is being made toward unity in standardization and specifications in the War Department and it is highly desirable that there be constituted a central body with authority for all departments. A single board, for example, to frame metal specifications for all would make for economy and efficiency.

That the technical public is now ready for such simplification and uniformity is evident by the recent creation, somewhat on the British model, of the Engineering Standards Committee. The Germans are also said to be forming a similar organization and the French and Italian governments have organized standards committees. It is to be hoped that this is one of the after-war activities to be pushed. It is not too much to say we have entered an era of standardization. It is not necessary before a group of scientific men, however it may be else-

where, to state that standardization necessarily involves research, often very elaborate and costly.

The relation of science to industry has been a fruitful subject for discussion in recent years, both here and abroad, and nowhere has the question of industrial research, as it is often called, been cultivated more intensively and made more progress as a direct result of the war than in Great Britain; and it may be of interest to mention briefly some of the steps in the progress.

Following the economic congress of the Allied Nations at Paris, there was formed in July, 1916, a committee presided over by Lord Burleigh on commercial and industrial policy after the war and the reports emanating from this body and its auxilaries cover the whole field of the economic aspects—industrial, commercial, technical and scientific—of the after-war period, and lay particular emphasis, for example, on the protection and development of "key" or "pivotal" industries, most of them requiring the highest grade of scientific and technical skill for their maintenance and advancement, such as sympathetic drugs, optical glass, chemical glassware and porcelain, dye stuffs, magnetoes, high explosives, etc.

It is of interest to note in passing that the questions of decimal coinage and the compulsory use of the metric system of weights and measures were also considered and their adoption not advised. The arguments advanced for this conservative stand, if valid, are of a nature that would seem to make it difficult ever to make the metric system universal. A transition period like the present has precedent for the establishment of such a simplification of units and standards; for the metric system originated during the French Revolution and the International Bureau was founded at the time of the war of 1870.

There has since been established in England a Ministry of Reconstruction to deal with the numerous problems the transition period presents. A Department of Scientific and Industrial Research with a Parliamentary Secretary has also been created and has been active for nearly two years: (1) Encouraging firms in well-established industries to undertake cooperative study of the scientific problems affecting their processes and raw materials, and has at its disposal a sum of one million pounds for grants on the basis of an equal subscription from industry; (2) the department has further prepared to undertake at the public cost investigations of general interest; (3) the importance to industries of the establishment of standards

of a scientific basis is recognized and the financial control of the National Physical Laboratory has been taken over, with provisions for pensioning the staff; (4) efforts are being made to increase the numbers of trained research workers which had reached a dangerously low ebb in 1915, as recognized by Lord Burleigh's committee, who found but forty qualified unattached persons available for research in the United Kingdom.

Very substantial results have already been achieved in these several fields and hardly a copy of *Nature* can now appear which does not record some new grant, technical committee, industrial research association or other advance in the interdependence of science and industry under governmental supervision. It is also especially significant to note that some of the industries are also standing on their own feet and establishing their own research laboratories along cooperative lines.

There is also the recently founded British Science Guild with a distinguished membership, which maintains lectureships and does much to foster the dissemination of the aims of research among the public.

This spirit of organized research has been contagious throughout the British Empire and there are being established similar associations, institutes and laboratories in Canada, Australia, South Africa and elsewhere.

Rather curiously enough in the democratic British communities, it is the government that appears to be taking the lead in the stimulation of scientific research, particularly in its relation to industry. It is probable that the reasons for governmental initiative are in part a result of the abnormal conditions of the nation at war, during which time individual efforts are much more difficult of effective expression—the community in the time of danger is thinking and acting as a unit under military stress and military methods predominate. As normal times return we may expect the state to relax its vigilance and the individual person, society or industry to reassert to a greater degree their qualities of initiative and independence. It is not improbable, however, that there is a genuine, conscious effort for the more generous support of research by the British public as a national asset, which support will be maintained in peace times on a much more extensive scale than in pre-war times.

Another incident significant of the trend of the times is the formation in October last of The British National Union for Scientific Workers with five hundred members, whose main objects, most worthy of repeating here, are: (1) to advance

the interest of science as an essential element of the national life, (2) to regulate the conditions of employment of persons of adequate scientific training and knowledge, (3) to secure in the interests of national efficiency that all scientific and technical departments in the public service, and all industrial posts involving scientific knowledge, shall be under the direct control of persons having adequate scientific training and knowledge.

The question that every scientific man in America naturally and perhaps unconsciously asks himself on hearing of such an organization is, of course, why not form such a union here? Indeed, the matter has been discussed in some centers and it would probably not be difficult to organize in the United States a similar union of scientific workers. Bodies somewhat similar already exist among various educational and professional groups. It should be borne in mind, however, in considering this matter that in addition to the general objects stated above, the scientific workers of England were almost compelled to organize in order to have representation on the so-called Whitley Industrial Councils, having to do with matters affecting labor and management relations in industry, and one of the creations of the reconstruction program.

Forming what is perhaps the natural corollary to the foregoing, there has been some serious discussion in Britain of the desirability of having representatives of science as such in Parliament; certain of the universities have had representation for a long time, but it is doubtful if the matter of representatives of science is pushed seriously. If science, why not literature, the arts and so on?

While we are considering the question of the scientific man himself, there is one phase of his relation to science and to industry that I can not pass by, which will need perhaps even more serious consideration in this transition period than it has had in the past. I refer to the bidding for his services by technical industries. A man who leaves the university or professional school and enters the research department of an industrial concern is not the man I mean. Is not the case different for a man who has chosen his career of scientific investigation in a university or other scientific institution independent of or under state control? This man, if taken from his environment by offers of financial gain, goes to enrich most certainly some special interest with his science and is still a valuable member of the community; but generally speaking, is it not of advantage to the community to keep that man contented in

his, what I am tempted to call, more natural environment? Natural, for he chose it and adapted himself to it. When the staff of an institution like the Geophysical Laboratory, to cite a most striking example, is largely absorbed by industry, does not the matter become of serious concern? Should not the industries rather be encouraged to take their scientific men when they are young and not break up growing scientific concerns? No doubt a certain amount of interchange in scientific personnel is to be encouraged, but it should be interchange and not bleeding practised by industry. Providing an adequate supply of scientifically trained men for the needs of industry and defining the proper relations between industrial management and scientific centers are questions meriting the most serious concern of the community. Our supply of scientifically and technically trained men is all too meager and if, as many expect, there is now to be a period of expansion in the foreign trade of the United States involving possibly the establishment abroad of numerous branches of highly technical industries, the demand for such men will become more urgent than ever, particularly with men of scientific training with engineering experience.

This brings us to the question of the education of scientific men, which subject it is possible to mention but briefly. Here again the interruption, disorganization and readjustment of educational training in America have been insignificant as compared with the disturbances in education brought about by the necessities of war of the European countries, but even in this country experiments with intensive training and shortened courses have been tried on a large scale, but, it must be borne in mind, for a limited period only. Our educational institutions will undoubtedly be able to preserve some of the beneficial characteristics brought out by such speeding up, but for the most part there probably will be little effect on the kind of training our scientific men will get.

It would appear to be highly desirable that as large a proportion as heretofore of our scientific men pass a portion of their preparative period abroad amid cultural surroundings different from those in which they grew up. As a beginning it is to be hoped that many of our young men now in France will be given the opportunity to take advantage of the generous offer of the French Government for instruction in the schools and universities of France. This, if carried out on a considerable scale, will have far-reaching effects, the benefits of which can hardly be overestimated. It is also to be hoped

our universities will not only encourage the coming of foreigners more than heretofore, but also render easier the migration of American students from one American institution to another. The establishment in Washington of schools framed on lines similar to the Ecole des Hautes Etudes and the Collège de France, which are devoted exclusively to research, would go far toward making more generally available the research facilities and scientific men of the capital.

During the war the scientific men of the country have been thrown into close association with each other, perhaps even closer in many instances than in pre-war times in spite of the decrease of attendance at scientific meetings and in the number of such meetings; in addition, there has been developed, as never before, acquaintance and cooperation of the men of science of this and the allied countries; and not only the men of one science have been thrown together but representatives of what we ordinarily consider very diverse sciences have been brought into close personal and professional contact. All this makes for the unity of science and the broadening of scientific men. It would seem desirable to make an effort to perpetuate this habit of association of scientific men from different countries. You will recall that in 1914 there were projected several international congresses in science and engineering. Would it not be well, as soon as circumstances permit, at least to revive these projected congresses with such limitations as comply with the conclusions reached recently in London by representatives of the national academies of the Inter-Allied Nations?

A very important matter that has been held generally in abeyance by the war and which will soon again require the serious attention of scientific gatherings is that of the policies regarding scientific publications. Very definite proposals have been discussed recently in England looking particularly to the avoidance of duplication, confusion and other anomalies in scientific literature and to its more effective distribution. This question again is a variant of the standardization problem and is further complicated by interests or prejudices, both national and professional, of numerous societies representing often if not competing, yet overlapping fields of science. For any particular branch of science, there are also the international aspects to be considered, including the question of language; and it is within the bounds of possibility, for example, that there will occur a revival of the more concerted efforts for the use of an auxiliary international language such as Esperanto,

or if you will a standardized, international form of expression in science.

If I have dwelt with less emphasis on some of the recent, strictly American tendencies of scientific development, I trust it fair to assume you are acquainted with most of them. The great work of the National Research Council is certainly familiar to us all and it is good news to hear that plans are being developed toward reorganizing the Council to meet the conditions of the reconstruction period. There is great need in the United States, with our relative geographical isolation and great distances between many scientific centers, for an active, scientific body devoted to the initiation, stimulation and correlation of scientific research.

Furthermore, by emphasizing the recent British developments in the relations of state, industry and science, I by no means desire to imply that we have not been active in America. These matters are being freely discussed here and many plans are being formulated and some are in operation, for cooperative research in various branches of science, particularly as applied to industry. The weekly and monthly scientific press are full of them. It is to be noted that in contrast with the British experience, in America less expectation is being placed on governmental aid to new research projects; an exception to this is of course the Smith-Howard bill now before Congress for promoting engineering research in the several states.

In America, individual initiative in the past has on the whole been more potent than the state in providing the funds for maintaining research. In the prosecution of the war now drawing to a close, however, the federal government has spent huge sums on projects requiring scientific investigation and development, and in order to carry out the scientific projects of military urgency, has mobilized the scientific men of the country. Is it well during the after-war period to demobilize completely this army of scientific men? No one would yet think of having no organized military force in peace time, and there is in every well-organized state always at least a skeleton army with all branches represented, including a competent staff, arsenals, depots, surplus munitions and supplies.

The great scientific bureaus of the government are organized for the problems of peace and, although they can give a good account of themselves under war conditions, yet would it not be well, at least until the millennium is more clearly in sight, to retain more than a nucleus of an organization of scientific men in the service of the state and especially in the mili-

tary and naval establishments? We can all name branch after branch of each of these services which before the war contained almost no scientific personnel but to which have been added during the war scores and hundreds of scientific men; and in some cases it was no easy matter to gather and coordinate this personnel.

What, therefore, appears to me as one of the very important problems of the transition period, namely, the proper balancing and distribution of the scientific forces of the country as between the military and civilian activities of the state on the one hand, and the industrial and academic activities of the country on the other, is even now undergoing the process of being solved. The readjustment will go on largely unperceived at the moment and the changes will be accompanied by the usual quiet but significant struggles. The more rapidly the world settles down to more stable conditions, the more promptly shall we reach this dynamic equilibrium of the distribution of scientific men and the balancing of competing fields in scientific research.

ENTOMOLOGY AND THE WAR

By Dr. L. O. HOWARD

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RATHER frequently during the past eighteen months, meeting friends, they have said, by way of casual conversation, "I imagine that the war does not affect your work especially." They did not stop to think of the very great importance of insects in the carriage of certain diseases, the ease and frequency of such transfer becoming intensified wherever great bodies of men are brought together, as in great construction projects, and especially in great armies. They did not realize, entirely aside from the especial diseases of this character met with by the troops in Africa, Mesopotamia and in the region of Salonika, that even upon the western front, in a good temperate climate, warfare under trench conditions was rendered much more difficult by reason of the prevalence of trench fever which investigations during the latter part of the war showed to be carried by the body-louse.

Moreover, with the same lack of thought which leads people to ignore the importance of the officers of the Quartermaster's Department as compared with those of the fighting arms of the service, they failed to consider, not only how damage by insects to growing crops influences the food supply of armies, but also how greatly grains and other foods stored for shipment to the front or on the way to the front may be reduced in bulk by the work of the different grain weevils and other insects affecting stored foods. In addition, they did not think of the damage done by insects to the timber which enters into the building of ships, into the manufacture of wings for the airplanes, and that which is used for oars, the handles of picks and spades, and which even occurs in such wooden structures and implements after they have been made—in the implements, not when in actual use, but rather in the period of storage and shipping. A striking example of this latter damage is seen in the history of the Crimean War, when England, after a long period of peace, provided the army which she sent to the Crimea with long-stored tools for the sappers and miners, and it was found that the handles crumbled through the work of *Lyctus* beetles.

As a matter of fact, war conditions have intensified the work of the entomologists and have enabled them to make the importance of their researches felt almost as never before.

Long before this country entered the war, the warring European nations had met with many of these problems in force. We know of the early ravages of typhus in the Balkans; we know of the loss through other insect-borne diseases in the eastern expeditions; and it is most interesting to realize that, although the need for the services of trained entomologists with the troops was not realized at first, later every sanitary unit in the British Expeditionary Forces carried two entomologists. Few people know that as early as 1915 there was a conference of all the principal official entomologists of Russia to consider the vital question of the loss to stored grains by weevils. Later this same matter was taken up by the British government, and her best economic entomologist was sent out to Australia to endeavor to safeguard Australian wheat accumulating at the seaports for shipment to San Francisco, to be milled in this country to replace the milled grain which this country had sent to England (this route of shipment being chosen to avoid the long sea haul from Australia to England with possible added weevil damage during the journey, to say nothing of submarine dangers).

The story of the early efforts of the European governments to control the body-lice which carry typhus, and, as found out later, trench fever, is interesting. Shipley in England published early papers and a book entitled "The Minor Horrors of War," in which everything that was known up to that time about lice was mentioned. In France, Houlbert published a pamphlet covering the same ground, and the women of France made an enormous number of camphor sachets for the troops to carry next their skin in order to deter lice. In Germany, Haase, stationing himself near a camp of Russian prisoners where living material was, to say the least, abundant, made, with that infinite attention to detail characteristic of the Germans, a careful study of the body-louse, and published a sizable book giving the results of his investigations. Attention to important details is admirable, but when a writer devotes several illustrations and a minute description to the method by which a louse, accidentally finding itself on its back, resumes its normal position with the back upwards, as Haase did, the practical reader is inclined to smile.

Later, however, much practical work was done by all these nations. Delousing stations were established; an admirable investigation of all aspects of the subject was carried on by Nuttall at the Quick Laboratories in Cambridge, England, and conditions were much improved before the United States troops began to mass and to be shipped across the Atlantic.

As will be remembered, one of the earliest matters taken up by the Congress of the United States after the declaration of war in April, 1917, was the consideration of appropriations for the stimulation of crop production, and in this consideration, naturally, one of the points was the control of the principal insect enemies of staple crops. Prior to any congressional action, however, the Bureau of Entomology started a country-wide reporting service on the conditions concerning these principal insect enemies, and engaged in excellent cooperation, not only all of the state entomologists, the entomologists of all of the agricultural experiment stations and the teachers of entomology in the colleges, but also the demonstration agents, the statistical agents, both state and federal, the weather observers, and the field men of the Forest Service. The idea was to bring about as far as possible almost a census of insect damage and prospects, so that the earliest possible information should be gained as to any alarming increase in numbers of any given pest and that this information should be received at a common point (Washington) and distributed where it should be of the most good, and that it would enable repressive measures to be undertaken at the earliest possible moment in order to check the threatened loss. All reports received in this way were digested and were distributed all through the growing seasons of 1917 and 1918 to the official entomologists of the country.

Soon after this service was instituted, the funds for food crop stimulation became available, and trained men were employed for demonstration work, to act in connection with the Extension Service of the Department and of the different state colleges of agriculture. These men were assigned to different localities, and took care of the demonstration work against the principal pests of staple crops all over the United States. Some of them were specialists in the insects which attack truck crops; others in those which damage field crops; others in those which affect orchards, and so on. Especial attention was given to the control of the grasshoppers which damage grain and forage crops and to the sweet-potato weevil, an insect which bids fair to seriously affect the output of the South of this important vegetable.

Aided, it is true, to a considerable extent by the winter of 1917–1918, which from its unprecedented cold had a destructive effect upon many important insect pests, and to a lesser extent by the character of the winter of 1916–1917, which also was a hard one for injurious insects, the economic entomologists, including the demonstrators, accomplished much. Owing to peculiar weather conditions in the early spring of 1917, cer-

tain insects not hitherto notably conspicuous appeared in great abundance and added new problems to the production of certain crops. A notable example of such insects was the potato aphis, a species which previously had done almost no damage, but which appeared in countless numbers throughout certain of the middle western states in the early summer of that year. Notable work was done with the destruction of grasshoppers by the poisoned bait method, and it is safe to say that many hundreds of thousands of dollars, perhaps millions of dollars, worth of food crops were saved in this unusually intensive work. A single instance among many may be given in more detail.

In the State of Kansas the season of 1918 was remarkable for one of the worst grasshopper outbreaks that have occurred in that state since 1913. The danger of this outbreak was recognized during the fall of 1917, and a grasshopper-egg survey was instituted in cooperation between the State Agricultural College and the Bureau of Entomology. The results of this survey showed that without doubt a great hatching of grasshoppers was imminent, and extensive cooperative plans were immediately made. Winter meetings were held throughout many of the counties in the western one third of the state, and the farmers were organized and plans matured for the purpose of purchasing bran in large quantities, and then prompt distribution of poison was made as soon as the grasshoppers began to hatch. In eight counties of the state 36,000 pounds of white arsenic in 366 tons of wheat bran were used in the preparation of poison bait, which was distributed in an amount exceeding 900 tons. The counties cooperated in most cases financially. As a result of this general application of the bait, it appears that some 113,000 acres of wheat were saved from destruction. Estimating fourteen bushels per acre, which is considered a full crop in western Kansas, with wheat at two dollars per bushel, this represents a value of approximately $3,000,000 saved in Kansas. This figure is considered conservative, according to the officials of the State Agricultural College.

In addition to the control work on grasshoppers affecting wheat fields, it is estimated that 25,000 pounds of poison bait was used throughout Kansas for the purpose of protecting alfalfa and sugar beets, and it is estimated that 100,000 acres of alfalfa in western Kansas was saved by this application. With alfalfa selling at $20 per ton, this represented $2,500,000.

It should be mentioned incidentally that all this control work bids fair to be greatly hampered by the derangement of the insecticide situation in this country, due to war activities. Not only was the importation of arsenicals stopped, but their

production was greatly limited by the fact that the smelters, from which arsenical compounds are gained as byproducts, were so rushed in the production of urgently needed metal that by-product industries were largely stopped, and by the further fact that more than a third of the actual production under these limitations was, toward the end, used by the Chemical Warfare Service. Nevertheless, the entomologists and the chemists and the insecticide manufacturers held frequent conferences as to how best to utilize the reduced quantity of arsenical insecticides to insure the protection of crops to the greatest extent possible, and it resulted that, although the amount of arsenic available was really insufficient to meet normal demands, yet by conservative use and better distribution the requirements of the farmers, fruit-growers, gardeners and others were met.

There might be mentioned also another side activity entirely due to war conditions. The extensive use of castor oil in airplane work made it necessary to grow the castor bean plant in great acreage in this country, since practically none was to be had elsewhere, the large Mexican crop having been bought up and sent to Spain, probably to secret German bases. Therefore, under government contract, thousands of acres of this crop were planted in Florida and elsewhere. Now, although the castor-bean plant had not hitherto been known to be subject to serious insect attack, the planting of these large areas was immediately followed by the increase of certain injurious insects and by serious damage to the growing plants by the southern army worm and other species. Entomologists were at once called in, and through rapid and able work much of the threatened damage was prevented.

In the meantime the entomologists were able to be of service to the country, and especially to the military forces, in other ways. The damage to stored grain and to grain in shipment, which has been previously referred to, soon came to the front. Enormous quantities of grain and other materials were accumulated at the port of New York for shipment to Europe. The immense warehouses at the Bush Terminal in Brooklyn were centers of accumulation of such material. The Bureau of Entomology was called upon for advice by the War Department, and a laboratory was stationed at this terminal where men experienced in the study of insect pests of this character were stationed, where competent inspection was made, and where arrangements were made for the proper fumigation or other treatment of stored products found to be infested with insects.

In addition to this work at the Bush Terminal in Brooklyn, experts on the Pacific Coast and in the South were engaged in the inspection of many warehouses and mills where food supplies were stored, and throughout the entire period large supplies of food that were being seriously affected by insects were located. The owners of such supplies were advised of the necessity of prompt action in order to avoid further losses, and were shown how to prevent losses of newly acquired supplies that were free from insects.

The same sort of work was done in regard to insects affecting lumber and stored wooden implements. Early in 1917 a conference was held with representatives of the branches of the War and Navy Departments, Shipping Board, etc., which were responsible for the supplies drawn from the forest resources of the country. The object of this conference was to offer the services of the entomologists and to explain how they could help, through special investigations and advice, towards preventing serious losses of forest resources and damage by wood- and bark-boring beetles. Investigations of logging and manufacturing operations in Mississippi to meet the demand for ash oars, handles and other supplies required by the war service showed, for example, that one company had lost more than one million feet of ash logs through failure to provide for prompt utilization after the trees were cut, thus preventing the attack of the destructive ash-wood borers. Serious losses to seasoned ash and other hard wood sap material from "powder post," it was pointed out, could be prevented through the adoption of certain methods of management by the manufacturers and shippers with little or no additional cost.

The urgent demand for spruce for the construction of airplanes led to an exceptional effort by the Spruce Production Board to utilize the great resources represented by the Sitka spruce of the Pacific Coast. It was soon realized that damage by wood-boring insects to the logs was a serious matter and that the advice of the expert entomologist was essential to prevent losses of the best material.

The problem was investigated by the entomologists and it was found that the prevention of the damage and loss was a matter of methods of management in the logging operations and prompt utilization during a short period in the year when the insects were abundant.

Early in the war and especially after the United States issued its declaration, the shortage of sugar made necessary an increase in the supply of supplemental sweets, and, since none of these could be increased more economically and more promptly than honey, and since none of them have a higher

value as food than honey, great efforts were made by the bee experts of the Bureau of Entomology to increase the honey production of the country. It was known that there was nectar available annually to provide for a profitable increase of ten or more times the then present honey crop, provided beekeepers were instructed in matters like proper wintering and disease control. So all apicultural investigational work, except that on bee diseases, was discontinued, and intensive extension work was begun. Specialists were sent out, held meetings, addressed more than 25,000 beekeepers, visited the apiaries, and gave personal instruction, with the result that the honey crop was greatly increased. Our exports of honey to allied countries have increased at least ten times over those of any period previous to the war, and in the meantime the domestic consumption of honey has greatly increased.

Returning once more to the important subject of medical entomology: During the period of the war the Bureau of Entomology has maintained a thorough cooperation with the Office of the Surgeon General of the Army in the matter of experimental work on insect problems. Under the National Research Council's Committee on Medicine, a sub-committee on medical entomology was established, of which the Chief of the Bureau of Entomology was made chairman, and Doctor Riley, of the University of Minnesota, and Doctor Brues, of the Bussey Institution of Harvard University, were the other members. Important work on the louse question was done by Doctors Moore and Hirschfelder, of the University of Minnesota, the former an entomologist and the latter a chemist, and by Doctor Lamson, of the Connecticut Agricultural College. Under this committee an enormous amount of experimental work was done with the different health problems in which insects are concerned.

For example, every suggestion that came to the War Department in regard to the control of the body-louse was referred to the entomological committee, or to the Bureau of Entomology, and those which were promising were experimentally tested, either at Washington or at Minneapolis, or, for a time, at New Orleans, where a branch laboratory was instituted. At the request of the Army War College and the medical department, as well as the chemical warfare service, tests were made of a new poisonous gas. This led to extensive experiments in cooperation with the chemical warfare service leading to the possible utilization of the gases used in warfare as fumigants for the control of insects and diseases. At the request of the Quartermaster's Corps a complete investigation was made of all of the processes of the American process of laundering

adopted by the Army, and also of the dry-cleaning processes and the hat-repair processes. In these investigations the cooperation of the entomologists of the Bureau of Entomology with chemists of the Quartermaster's Corps resulted in the perfecting of the laundry processes so that it is now possible to guarantee the complete control of vermin in the laundry if the laundering is carried out according to the methods recommended, which are very slightly different from those in common use. It was found that the laundry machinery gave ample means for any sterilization of clothing necessary. In the investigations of the dry-cleaning processes it was found that the entire process gave complete control of vermin, but that gasoline treatment alone was not a perfect control. This discovery led to a long series of important studies of the effect of various densities of oils on insect eggs. At the request of the Chemical Warfare Service various substances and impregnated clothes devised for the protection of soldiers against gas were also tested as to their effects upon vermin. By a special request of the Electro-Therapeutic Branch of the Office of the Surgeon General of the Army, investigations were made of a high frequency generator as a control means against the body louse, and as a result of these investigations suggestion was made as to the possible application of high frequency electric treatment for the control of scabies and other skin-infecting parasites. Cooperative investigations along this line are about to be taken up.

Among other problems investigated were the size of the meshes in mosquito bar necessary for the protection of cantonment buildings from disease-carrying mosquitoes; reports on the insects likely to be found injurious to troops sent tó Siberia; investigations of the protective qualities against lice of furs dyed in various colors, and so on.

A series of lectures dealing with important sanitary problems from the insect side were mimeographed and were sent to persons in the Army, Navy, Public Health Service, and in civil life who were preparing themselves for, or who were actively engaged in sanitary entomology.

Aside from this extensive cooperative research, entomologists were actually used in the Army, a number of them being given commissions while others acted as non-commissioned officers, assisting in the camp work on the control of insects that carry disease. The commissioning of expert entomologists for this kind of work was difficult, owing to the organization of the Army, but had the war continued, it is safe to say, more and more entomologists would have been employed in this im-

portant work, whether commissioned or not. The records made by a number of these men were admirable and met with well-merited praise in Army circles. In great concentration camps in several instances entomologists were placed in entire charge of matters of mosquito and fly control, under medical command or under sanitary engineers.

In addition to this cooperation with the Army itself, the Bureau of Entomology has also cooperated with the Public Health Service, which had the extremely important work in charge of the health control of areas immediately surrounding the concentration camps, and has held itself ready to assist in this work whenever called upon.

This statement of the work of the entomologists during the war might be extended very considerably. Many additional instances of the value of their labors might be detailed; but perhaps the impression which will be left by what has just been said will be quite as strong as if more facts were added and more time used.

Perhaps this is an opportunity, however, to call attention in a striking manner to the work which the economic entomologists are doing all the time. While all this other intensive work was going on, for example, the federal entomologists were making a great fight in Texas by which the pink bollworm has apparently been absolutely wiped out in the districts in the United States infested last year and at the same time there has developed a system by which damage done by the cotton boll weevil can economically be greatly reduced, which may be said to be the culmination of the work of many years.

Incidentally it may be mentioned that the preeminently practical men who have, under the state and federal governments, been working for years in this extremely practical and important field, had supposed that the value of their work was generally recognized and that they were known to be scientifically trained and competent investigators whose advice and help meant everything in the warfare against insect life. But they were surprised and chagrined to find that even in certain high official circles the old idea of the entomologist still held—that he was a man whose life was devoted to the differentiation of species by the examination of the number of spines on the legs and the number of spots on the wings. The economic entomologists are thus evidently still unappreciated. Shall they change the name of their profession to avoid the survival of the old association with trivial things, or shall they work steadily on with the ultimate hope of gaining the confidence and respect even of the old-fashioned element of the people?

THE NEXT STEP IN APPLIED SCIENCE

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IT was long ago that Plato taught that science should not be applied to the mechanical and industrial arts, but to education, social culture and social health. And a century and a half have passed since Rousseau's celebrated essay, in which he tried to show that the arts and sciences had done nothing to advance human happiness. From our modern view-point these were the pathetic mistakes of great men, so richly, as we think, has science vindicated itself in its practical applications.

Consequently, when the term "applied science" came into use not many years ago, it was heralded with great joy, for we were weary of Plato's theoretical ideas about justice and truth, and skeptical about his plan for racial culture, and we longed for something practical and immediate. We welcomed, therefore, the direct application of science to our every-day needs, and when, in response to this demand, science began to shower its practical applications upon us, it seemed to many that a kind of golden age had come at last. It revealed to us the only god worthy of our worship—the god of social welfare, social welfare being generally interpreted to mean the comfort, happiness and convenience of the present generation.

While we may not question the almost unlimited possibilities in the application of science to social welfare, nevertheless, we may raise the question whether science has thus far been applied to the right things. The war has shaken the foundations of so many of our accepted opinions that even our faith in applied science may receive a rude jolt. Since we are now entering upon a period of reconstruction, which many believe will involve not only our social and political ideals, but also our ethical and religious beliefs, it is legitimate enough to ask whether applied science has vindicated itself by its results and what place it is to occupy in the coming order.

Our first thought is that applied science has been not only a stupendous success, but perhaps the crowning achievement of the human mind. The story of its triumphs is known by heart to every school girl. Applied science has made the world over, making it a decent and healthful place to live in. We

press a button and our houses are filled with light. Scientific heating, ventilation, drainage and sanitation have made our homes places of cheer, comfort and health. The motor car, smooth, noiseless and swift, saves our time and our nerves. Time-savers too are the typewriter, the dictograph, the multigraph and the adding machine. Communication is facilitated by the wireless telegraph, the telephone and the aerial mail.

It is needless to go through the familiar list. Lest, however, it should be thought that applied science has given us only comforts, conveniences and time-saving devices, we are reminded of its triumphs in the conquest of disease, in public sanitation, in surgery, dentistry and preventive medicine, and in the application of chemistry to agriculture. And, most manifest of all, are the countless applications of science to the industrial and mechanical arts, increasing the efficiency of labor, thereby shortening the hours of the laborer, as well as ministering to his comfort and health. Certainly applied science has made the world a tidy place to live in and contributed an untold sum to human happiness and welfare. Surely, had Rousseau lived in the twentieth century he would never have written, even for the sake of a brilliant paradox, an essay questioning the value of the arts and sciences to civilization.

We may not, indeed, question the potential value of applied science, nor even its actual value in countless directions. What we may question is whether there has been a mistaken conception of the general end to which science should be applied in respect to real social welfare. To what extent has science, as it has actually been applied, contributed to human good?

First, applied science has surrounded us with comforts, conveniences and luxuries of every kind. But just what will be the effect upon a race of men, disciplined through a hundred thousand years of hardship, of this sudden introduction to comfort? This question puts the whole subject of applied science in a new light. Perhaps we have been applying science to the wrong ends. Possibly science should never have been applied to making man comfortable, but to making him perfect. It may be that there is great danger in comfort. The biologist holds it in grave suspicion. Degeneracy is its sequel. It was through struggle and warfare and the overcoming of obstacles that man fought his way up to manhood. With infinite effort he gained an upright position the better to strike down his enemies. Strong legs and stout arms were the correlates of his growing brain, the latter itself finding its necessary support in a powerful heart and vigorous digestive system. There is an

especially intimate connection and interdependence between the brain and the muscular system, making the latter indispensable to the proper functioning of the former. Now, applied science has shown us how machinery may take the place of the stout arms and the motor car may be a substitute for the strong legs, while science itself and the applications themselves draw more and more heavily upon the powers of the brain. The harder the brain has to work in the pursuit of science and the mechanic arts, the more it stands in need of the physiological support of the muscular, digestive and circulatory systems. But, for maintaining the health and integrity of these, our present manner of living is not well adapted.

"Oh, well," it is replied, "there are no signs of physical degeneration yet. Look at our armies. Finer physical specimens never marched out to meet an enemy." This is true and we may add—braver ones never went to war and they were 100 per cent. efficient. Yes, but they were picked men, the very flower of a vast nation. They were from the upper tenth physically. They were the young males. They were the 65 per cent. of the young males not rejected by the examining boards. The germ-plasm of the best of our race could not suffer deterioration in the short time of the "comfort" régime. But upon biological grounds we must believe that the disastrous consequences of such a régime upon society as a whole may be serious in the highest degree.

Another of the most brilliant triumphs of applied science is seen in our countless and wonderful labor-saving devices. The effect of these is either to decrease the amount of labor or by increasing its efficiency to increase the products of labor. But we simply *assume* that increased wealth and decreased labor are human blessings, although both may be quite the opposite. It has been seriously questioned whether civilized man has gained enough moral and physical poise to be trusted with the immense wealth which applied science, working upon our suddenly acquired store of coal and iron, has supplied. The war did not count the poverty of the nations among its causes, and if greed is the root of most modern evils, it has not been shown that increasing wealth and increasing comforts have lessened it.

Again, just why has it been assumed that *labor-saving* devices are a human benefit? Work, and indeed physical work, is a blessing, not a curse. During the past history of man, which we may reckon in hundreds of thousands of years, Nature has said to him, "You must work or die." Labor-saving

devices, discovered at a recent moment in this vast history, may enable one half the members of society to live without work and reduce the working hours of the other half, with results most pleasing for the moment, but perhaps most disastrous in the end.

Is it not conceivable that applied science might be used not only to reduce the hours of labor of those who are now crushed with *excessive* labor, but to devise means of preventing the disastrous biological consequences which must follow the cessation from healthful labor among a considerable portion of society?

And then there are the time-saving devices. It is no doubt because of the temper of the day that so few of us have ever questioned their intrinsic value. But with all these time-saving devices it is not quite apparent that we have any more time than formerly. Sometimes it seems as if we have less. Leibniz lived before the time of typewriters and dictographs, yet he is said to have had a thousand correspondents and in addition to his duties as court librarian, diplomatist and historian, he found time to discover and perfect the differential calculus and to write great works on philosophy. In any case the value of time-saving devices will depend upon the use of the time that is saved. As it is, it appears to be used very largely for carrying on more business, to make more money, to buy or invent more time-saving devices. Even if there results a certain amount of leisure, much depends upon the manner in which the leisure is spent. If it is spent in sitting quiescent in a darkened moving-picture room, gazing spell-bound at a tawdry drama, the gain is not great.

In all our plans for improved economic and social conditions, it is uniformly taken for granted that leisure, resulting from a shortened working day or from time-saving devices, will be an unmixed good. Leisure in itself is not good; it may be dangerous. There have indeed been epochs in history when men, released from labor by wealth or otherwise, have turned their thoughts to beautifying their environment and surrounding themselves with works of art. At such times, too, poetry, music and the worthy drama have flourished. Is it quite certain that we are now living at a time when mankind can be trusted with leisure?

To all such arguments as the above it will be replied that modern science has nevertheless made the world a decent and comfortable place to live in and that there has never been so much happiness in the world as at present. But, for the last four years Europe has not been a decent nor comfortable place

to live in nor has there been general happiness, although Germany excelled in its development of science and in the application of science to the mechanic arts. A good civilization must insure some degree of stability.

In this connection we are reminded that there is one field in which science has distinguished itself beyond all others, and that is in the art of war. To the exquisite perfecting of this art every science has been called upon to contribute its very best and latest results—mathematics, engineering, physics, chemistry, metallurgy, mechanics, optics, radio-activity, electro-dynamics, aeronautics, economics, zoology, psychology and many others. An immeasurable weight of the best and keenest thought of the world has been expended in the application of science to the paraphernalia of war, resulting in an amazing progress in the development of this art to the highest conceivable degree of perfection.

If in defence of this kind of application of science one should say that by this art civilization has been saved, it would only be because by this art it was threatened. Given an unscrupulous nation dreaming of world dominion and harassed by the need of commercial and industrial expansion, that nation would never have dared to venture on this ambitious project, had it not been for the fact that she found herself in possession of such an arsenal of cunning devices as to make success apparently certain—submarines and superdreadnaughts, mines and torpedoes, airplanes and monster dirigibles, titanic cannon and marvelous machine guns, secret formulæ for super-explosives, poison gases and liquid fires—these are some of the implements of war which applied science had put into her hands.

The results, whether one choose to regard them in terms of sorrowing homes, of outraged and degraded morals, of the loss of the best young blood of all the nations, of enslaving national debts, of the disorganization and ruin of world commerce and industries, or of the destruction of art treasures, are equally appalling.

If, as many believe, one of the prominent causes of the war was the urgent need which Germany felt for commercial and industrial expansion, we seem in this very fact to have an indictment of the mechanic and industrial arts, when viewed in the light of the leading motive in the social order. Nowhere else in the world had science been applied so extensively and successfully to the satisfaction of human wants as in that country. Yet these wants were not satisfied and Germany had to

fall back on the age-old method of the exploitation of other nations. But we are evidently coming to the time when this method will not work. Perhaps it may be a long time before it will again be tried. Each nation must satisfy its own wants by peaceful means, and thus the question faces us whether any possible development of the mechanical and industrial arts, upon which we rely so fondly, will satisfy the desires of man.

In former times wars acted to purify racial stocks by eliminating weak races. Modern wars have precisely the opposite effect, owing to the fact that a modern war kills or disables the best young men of all the warring nations, and so, by destroying the most valuable germ-plasm of the race, causes irreparable damage to society. Applied science has devised every conceivable means to make the destruction complete. Would it not be well, therefore, in the years to come for science to apply itself directly to the problem of preventing wars? It is idle to say that they can not be prevented or that science has nothing to do with this problem. It lies distinctly within the field of such sciences as biology, psychology, sociology and education. For applied psychology it offers a most alluring field. It may be an immense problem but the possibilities of science are immense.

At present we are depending too largely upon political readjustments to prevent war. The strong arm of international law is to be invoked to repress any aspiring belligerent nation. This is no doubt well, and may put a check upon wars between nations, but the menace of civil war will be ever present. A great nation may be torn asunder by a dispute about slave labor or a quarrel over religious creeds; mere rivalries between families, clans and classes may cause the streets of great and beautiful cities to run with blood, or a whole nation may simply lapse into civil war as a result of the disintegration of outworn political institutions. Any of these causes seems less promising for war than the conflict of labor and capital which is facing us.

We have thus in the preventing of war a real problem for applied science, especially for applied psychology. Let us, by all means, make over our laws and our international relations to the end of preserving order, but let us direct our main endeavors to making over our men and citizens so that they will have sense enough to settle all their disputes and controversies in some more rational way than by blowing out each other's brains with high explosives or by dropping bombs from aeroplanes to destroy buildings that they have erected with infinite

labor. Education will be efficient here, but it is an especially attractive field for applied psychology. The source of war is in the human brain, where the instincts of combat lie deeply imbedded, sanctioned through the warfare of thousands of years of human history. To eradicate these instincts may be difficult. To substitute some other form of expression for them may be possible. At any rate it would be worth while to turn in these directions a fraction of the brain power which has been expended in the invention and circumvention of the submarine boat or in the transmission of messages by means of the ether.

But it may be said, if applied science has not contributed as much to human welfare, as first appears, in the field of mechanic arts, nevertheless there are other fields in which its contributions are unquestioned, notably in hygiene, sanitation and agriculture.

The deep obligation which the world owes to applied science for its work in social and domestic hygiene, in applied bacteriology, in surgery, dentistry and preventive medicine, is appreciated by everybody. But the question arises whether even here science has been applied in just the right direction.

Let us take dentistry as a convenient illustration. This highly perfected modern art has given us beauty and symmetry of the teeth, replacing the deformities which formerly were so unsightly, particularly among older people. But obviously we have here not a remedial art, but a patching-up process. Crowns and bridges and artificial substitutes, themselves often the sources of infection disturbing the health of the whole body, have replaced the sound white teeth which nature should supply. At one time in our racial history sound teeth were necessary to the survival of an individual. They are scarcely so at present, for with artificial teeth and soft prepared foods one may get along very well and one's children may inherit the inner defects. This process can not go on forever. Under the old régime, before the rise of modern dentistry, there was at least a force, powerful if not always effective, working to the end of sound natural teeth. The dentist's art has to a large extent displaced this force. Is it too much to conceive of a new dentistry which shall have for its object not to make people look better, but to make them really better? If it is replied that this is precisely what the most recent dental art aims at in its teaching of oral hygiene, it is still true that this work relates largely, if not wholly, to the individual, for such acquired characters are not inherited, so that dental de-

generation may be going on unchecked, as has been shown to be the case in England. The problem may be a difficult one, but not necessarily beyond the power of applied science.

Then there is the conspicuous instance of the apparent triumphs of applied science in the conquest of modern diseases, particularly those of bacterial origin. Science has discovered, for instance, the cause and cure of tuberculosis. What greater boon to humanity could there be than this discovery, with its keen diagnostic technique, its therapeutic methods and its fresh air cult? It would appear, however, from no less an authority than Professor Karl Pearson that the death rate from tuberculosis has been decreasing as far back as our records go and that since the introduction of the new methods of treating this disease, which date from about 1890, the decrease in the death rate has been less rapid than before. Neither is this startling situation due to an increase in urban or factory life, as is shown by the recent rapid ravages of this disease in rural districts. Even though the accuracy of Professor Pearson's statement may be questioned and even though it be true that many diseases are now diagnosed as tuberculosis which were formerly classed under other names, nevertheless it is becoming clear that this branch of applied science has not been so sweepingly successful as was at first hoped, and that it may be well to supplement nature in her efforts to produce a degree of immunity to this disease by strengthening constitutional resistance. Methods of accomplishing this end are well understood now, since the Mendelian laws of heredity became known. It is only necessary to *apply* this branch of science.

In respect to general social hygiene, the benefits conferred by applied science seem certainly at first sight to be unimpeachable. One thinks immediately of our clean houses and our clean cities, of our comparative freedom from the scourges of smallpox, cholera, typhus and malaria, which in former times decimated the people. One thinks, too, of the marvelous triumphs of sanitation in the Panama Canal Zone and in our colossal national army, army camps and cantonments, both at home and abroad. One thinks of our efficient and sanitary hospital service, of our wonderful restorative surgery, our orthopedic art, and our discovery and application of anesthetics to the relief of pain.

The benefits, at least to the present generation, of this social hygiene are so patent that few of us have stopped to question whether it is strictly speaking social hygiene at all, or, if it should be so called, whether it is the highest kind of

social hygiene. Social hygiene must have as its end a really healthy people, not a weakened race which at every turn must be corrected and protected by artificial means. Our method of combating epidemic diseases has had for its two main objects the protection of the individual from infective agencies and the discovery of neutralizing antitoxins. Little attention, one might say almost no attention, has been given to making the individual constitutionally resistant to these agencies. It is perhaps a losing game to try to protect the human race from toxic and infective agencies. Brilliant temporary results may be gained, but a new swarm of microscopic enemies will ever be on the scene to take advantage of their weakened victims. So while we gain control over smallpox and typhus by constantly repeated devices, epidemics of infantile paralysis, influenza and pneumonia cause us to renew our Sisyphean labors.

In the meantime, while we are making headway against typhus and malaria and perhaps against tuberculosis, we hear of the increase of cancer, venereal diseases, diseases of degeneration, diseases affecting the heart and arteries, diseases of the digestive and eliminative organs and of mental diseases and diseases of the nervous system. We are perplexed to hear that the percentage of mothers who are willing or able to nurse their own babies becomes yearly smaller. While applied science has shown us how to quadruple our wealth and increase indefinitely the fertility of our soil, it has shown us how to decrease the fertility of our women, and since the new art is becoming fashionable among our best people but not among our worst, we have the unhappy prospect of actual racial deterioration, already evinced by the increase of poverty in a world teeming with wealth and by an increase of feeble-mindedness, insanity and crime. When bank robberies flourish during a time of unlimited prosperity, at a time when almost any person can get work at almost any wages, it would appear that the trouble is not in our social institutions but in the convolutions of our brains.

Nature seems to have discovered many ages ago that the way to make any race of animals or men strong and hardy was not to shield them from their enemies, but to give them power of resistance against their enemies.

Is it too much to hope that in the period of reconstruction to which we are looking forward, science may be applied less to shielding us from all manner of dangers and evils and more to making us strong to overcome evils; less to the production of comforts and conveniences and more to the encourage-

ment of hardihood and vigor; less to the increase of efficiency and the piling up of wealth and more to the production of racial health and stability?

Science has always been applied, and successfully, to our immediate needs as they were understood. The immediate needs of our present time are not more wealth and more luxury and more efficiency, but more racial and constitutional power of resistance to physical disease and more individual power of resistance to every alluring immediate joy which threatens the permanent welfare of society. We need steadiness and self-control and the limitation of our desires. The centrifugal motive which has ruled the world for the last fifty years has gone far enough. The world is small and there are limits to the expansive opportunities both of the nation and the individual.

Germany complained before the war that she was bound by a surrounding iron ring. To be bound by an iron ring is irksome. She longed for expansion. Hereafter expansive nations will understand that they can expand upward or downward at will but not sidewise, because other peoples also have rights. But individuals will have to learn the same lesson of limitation and self-government, and classes within a nation will have to learn it, else international troubles and even civil wars may take the place of collisions between states.

This, of course, will be applied science in a broad sense, applied psychology, applied ethics, applied sociology, applied biology, applied philosophy—and the growing interest in these sciences is one of the fine things of the present time.

Specific directions in which science may be applied to human welfare are found in conservation and education, and in eugenic control. Science has already been applied to the conservation of our soils and forests. It must be more widely applied to the conservation of all our physical and mental resources and particularly to the conservation of racial values. It may be feared, however, that both these forms of conservation imply a degree of self-control and limitation of desires which is foreign to the spirit of this individualistic age.

In the reconstruction era which we are approaching, the danger is that in the spirit of the times we shall attempt to solve the profound social problems which confront us mainly in two ways, first, by the further development of the mechanical and industrial arts, and second, by the manipulation of political institutions. We shall try, by means of new labor-saving and time-saving devices and new mechanical appli-

ances, to multiply still further the wealth of the world. We shall try, by means of some form of socialism or syndicalism, to provide that this wealth be more equitably distributed than it is at present. We shall try by the further extension of democracy and by equal votes for women to provide that justice prevail more widely than now. We shall try by sumptuary laws and by a league of nations to see that drunkenness and child labor are prohibited and wars between nations abolished. And, then, when all these things are accomplished, we shall look for peace, happiness and plenty to reign on earth. Just here is the source of possible defeat. It is not that socialism and votes for women and extension of democracy and a league of nations are not proposals of the very highest value. It is only that we shall depend too much upon these things for the salvation of society, and shall insist too little upon such other factors as conservation, self-control and the limitation of desires.

A good society will depend more upon the materials of which it is composed than on the forms in which these materials are put together. It does not take many laws or many social institutions to make a good society out of good men but it is doubtful whether laws and political and social institutions can make a good society out of evil men, and if this saying seems as trite as it is true, we must remember that the evil in men has a physiological basis and that its cure is not wholly beyond the possibilities of applied science. Suppose, for instance, that this problem were attacked with the same magnificent confidence as that displayed in the giant task of linking two oceans at Panama, or navigating the air, it would yield to the limitless power of the human intellect.

A BOTANICAL TRIP TO MEXICO. I.

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DURING the summer of 1910 the writer made a trip to Mexico for the purpose of investigating the forage conditions and collecting specimens of the grasses. He was accompanied by his son, Frank H. Hitchcock, as assistant. The technical report upon the grasses has already been published.[1] A brief statement of the topography and climate of Mexico and a record of some general botanical and agricultural observations were also prepared but were never published. The following account is adapted from that manuscript.

GENERAL REMARKS

In its general aspects the character of the flora of a country depends chiefly on the climate, and this in turn is greatly influenced by the topography. It is therefore advisable to outline briefly the topographic and climatic features of Mexico.

Topography.—The portion of Mexico lying north of the

MAP SHOWING THE APPROXIMATE LOCATION OF THE 500-METER INTERVAL CONTOUR LINES. The 1,500-meter line outlines roughly the plateau region which culminates in the vicinity of Mexico City where there is a considerable area above the 2,500-meter line.

[1] Mexican Grasses in the U. S. National Herbarium. Contr. U. S. Nat. Herb. 17: 181–389. 1913.

THE MAXIMILIAN CHAPEL IN THE OUTSKIRTS OF QUERÉTARO. Erected by order of the Austrian Government in 1901 to mark the spot where Archduke Maximilian was executed in 1867.

A DESERT SCENE NEAR AGUASCALIENTES.

Isthmus of Tehuantepec consists of a plateau, mostly 3,000 to 8,000 feet in altitude, with a strip of low land along each coast. Upon the plateau are numerous mountain ranges and mountain peaks rising above the general level. The most important range is the Sierra Madre, a continuation of the Rocky Mountain system of the United States. Certain peaks rise to a considerable height, and form conspicuous landmarks over a wide area. Among these may be mentioned Orizaba (18,225 ft.[2]),

A DESERT SCENE NEAR TEHUACÁN, SOUTH OF PUEBLA. Cactuses, agaves and thorny shrubs abound, giving the region an aspect similar to that of southern Arizona.

Popocatepetl (17,782 ft.), Ixtaccihuatl (16,060 ft.), all lying along the eastern edge of the plateau and capped by perpetual snow, Toluca (14,900 ft.) and Nevada de Colima (14,370 ft.) in the states of the same names. The strip of low land along the Atlantic coast varies from about 25 miles wide in parts of the state of Veracruz to over 100 miles wide in the state of Tamaulipas. On the Pacific coast the coastal plain is narrow except toward the north where it widens in Sonora to about 100 miles. The coastal region up to about 1,500 feet altitude is known as the *tierra caliente* or hot country, though the region up to about 3,000 feet, in the southern part, has essentially a tropical climate. On the east side the low country near the coast is dryer than the eastern slope of the plateau.

[2] The altitudes are taken from Terry's "Mexico," p. cxxvi, 1909.

Map showing the distribution of the annual rainfall (in inches). The rainfall increases toward the south and reaches a maximum in the Isthmus of Tehuantepec. Yucatan is drier.

Climate.—The winds from the Gulf deposit a portion of their moisture on the coastal plain but the maximum precipitation is reached only in the cooler altitudes. This is well shown by the annual rainfall of Veracruz (1,725 mm.) and Córdoba (2,867 mm.). After passing the eastern slope of the plateau the winds are comparatively dry and the interior is in consequence an arid region. The rainfall of Puebla, about 80 miles west of Córdoba, is only 923 mm. A similar but more striking contrast is shown by the conditions upon the eastern and western slope of Mt. Orizaba, though the rainfall data are not available.

Rainfall.—The northern portion of Mexico is arid, the annual rainfall being less than ten inches (25 mm.) The precipitation increases southward and reaches its maximum in the southern part of the state of Veracruz and in the coastal portion of Chiapas. The accompanying map shows approximately the distribution of the annual rainfall.[3]

Over most of the plateau region the rainy season lies in the months from May or June to September or October.

Hann[4] gives a table showing the average annual rainfall in

[3] "Distribution de las lluvias en la Republica mexicana," Carta formada por el Twg. Geographo Guillermo B. y Puga. At the Weather Bureau, Washington, D. C.

[4] Hann, Julius, "Handbuch der Klimatologie," 2: 324. 1910. Another source of information on the rainfall of Mexico is Memorias de le Sociedad Científica "Antonio Alzate," Vol. 16, 1901.

millimeters by months for several stations in Mexico. From Hann's table have been selected the following representative stations:

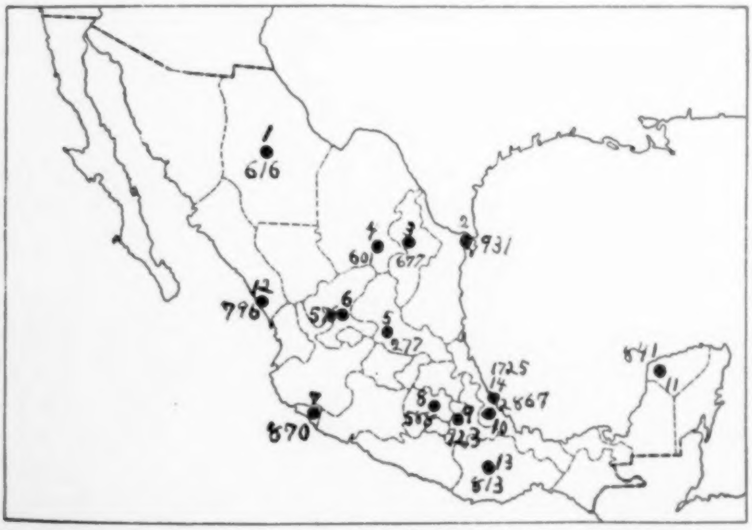
TABLE I

ANNUAL RAINFALL OF REPRESENTATIVE STATIONS IN MEXICO

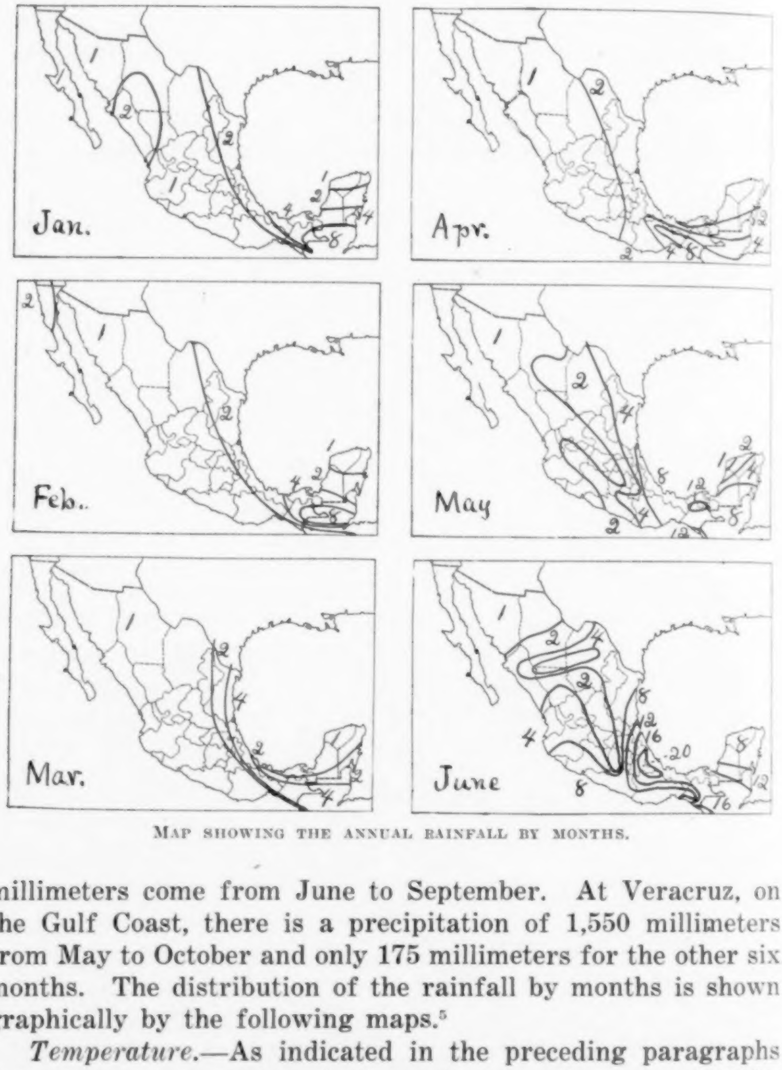
Station.	Annual Rainfall Millimeters.	Inches (approximate).
1. Chihuahua	616	24
2. Matamoros	931	37
3. Monterey	677	26
4. Saltillo	601	24
5. San Luis Potosí	277	11
6. Zacatecas	578	23
7. Colima	870	35
8. Mexico City	588	23
9. Puebla	923	37
10. Córdoba	2867	114
11. Mérida	841	33
12. Mazatlán	796	32
13. Oaxaca	813	32
14. Veracruz	1725	69

The accompanying map shows the location of these stations.

Hann's table gives the monthly rainfall for nineteen stations. In all cases there is a marked increase for the months of summer and autumn over those of winter and spring. At Chihuahua, in northwestern Mexico, two thirds of the precipitation occurs in July, August and September. At Zacatecas, further south on the plateau, nearly half the precipitation is in June and July. At Mexico City 428 out of a total of 588



MAP SHOWING THE ANNUAL RAINFALL (IN MILLIMETERS) FOR SEVERAL STATIONS IN MEXICO. The figures refer to Table I.



MAP SHOWING THE ANNUAL RAINFALL BY MONTHS.

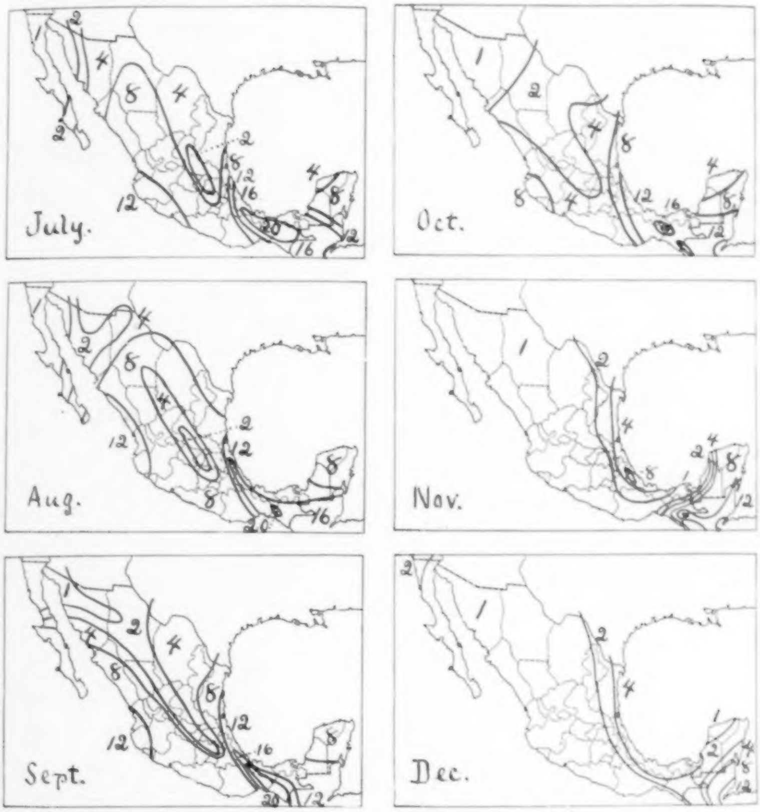
millimeters come from June to September. At Veracruz, on the Gulf Coast, there is a precipitation of 1,550 millimeters from May to October and only 175 millimeters for the other six months. The distribution of the rainfall by months is shown graphically by the following maps.[5]

Temperature.—As indicated in the preceding paragraphs the average temperature is dependent largely upon altitude. The seasonal variation is comparatively small except for the northern cities, Matamoros and Monterey.

Hann[6] gives a table showing the average monthly temperature, centigrade, for several stations in Mexico. No records are given for the northwestern portion of the Republic. For the cities of the plateau region from Zacatecas to Oaxaca, the records show a fairly uniform range through the year, the maxi-

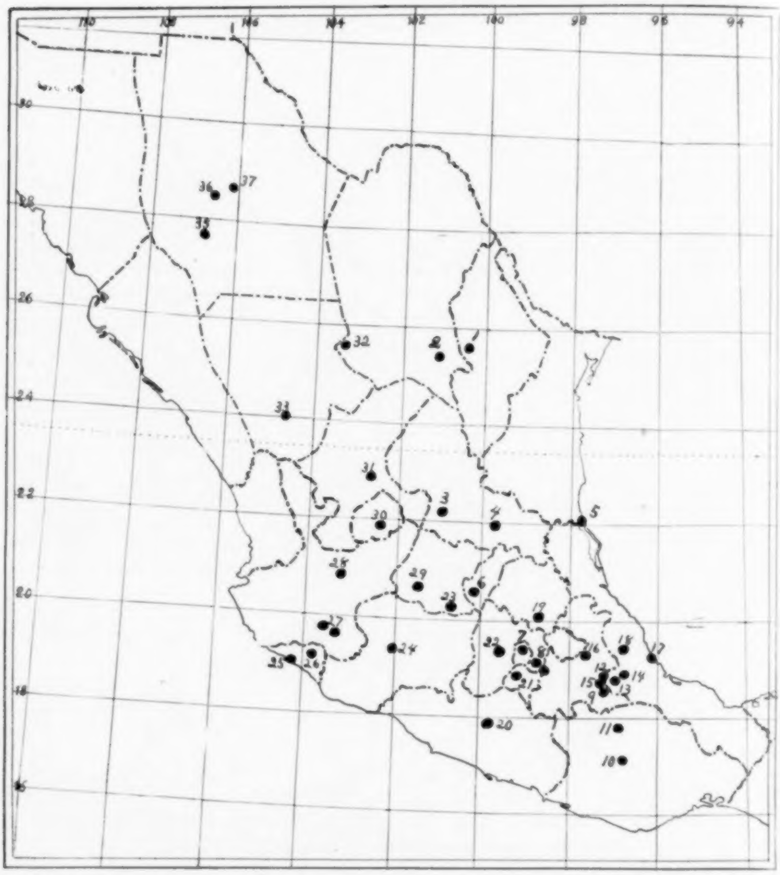
[5] From "The Distribution of the Rainfall over the Land," by Arthur J. Herbertson, London, 1900, an extra paper published by the Royal Geographical Society.

[6] *Op. cit.*, 321.



MAPS SHOWING THE ANNUAL RAINFALL BY MONTHS.

mum in May and the minimum in December and January. At Zacatecas, Mexico City and Puebla the average temperature for May is about 18.5° C. (65° F.). The average for December and January is about 12° C. (54° F.) for Mexico City and Puebla, and slightly lower, about 11° C. (52° F.), for Zacatecas. At Real del Monte, a city located at a higher altitude than those mentioned, the average for May is only 14.8° C. (59° F.) and for December only 10° C. (50° F.). The cities of Jalapa, Mirador and Córdoba, lying along the eastern slope from the plateau and about the latitude of Mexico City, show annual fluctuations about the same as those for the plateau but the temperatures are higher. At Jalapa, with an altitude of about 4,600 feet, the average for May is 20.4° C. (69° F.), and for December and January is 14.5° C. (58° F.). At Mirador (3,600 ft.) and Córdoba (2,700 ft) the average for May is 23° C. (73° F.); for January, 16.6° C. (62° F.) for the former, and 18° C. (64° F.) for the latter. At Veracruz, situated on the Gulf Coast, at sea level, in about the same latitude,



MAP SHOWING WHERE COLLECTIONS WERE MADE DURING THE SUMMER OF 1910. The numbers refer to the stations given in Table II. In 1908 the writer visited Guaymas and Hermosillo in the state of Sonora which lies west of Chihuahua and is the northwestern state on the map.

the average temperature is considerably higher. The five months from May to September show monthly averages of 27–27.7° C. (80–82° F.), while the comparatively cool months of December and January show averages of nearly 22° C. (71° F.). Tuxpan, a more northerly coast town, shows even higher averages, and Tampico, a coast city still further north, shows a summer temperature about the same as Veracruz but a winter temperature somewhat lower. Mérida, in Yucatán, shows a maximum average in May of 28.5° C. (83° F.) and a minimum in December of 22.4° C. (72° F.). The monthly averages for Mazatlán, on the Pacific Coast, show a gradual maximum from June to September of 27–28° C. (81–82° F.) and a minimum in January of 19.3° C. (67° F.). The temperatures increase during the dry season, reaching a maximum

A VIEW ON THE PEDREGÁL, NEAR MEXICO CITY. This is an extremely rough lava area about six miles long and three miles wide. The flora consists mainly of desert plants.

THE FLORA OF THE PEDREGÁL. The aspect of the Pedregál is similar to that of the aa or rough lava streams in the Hawaiian Islands.

just before the beginning of the rainy season which is usually in May or June.

Itinerary.—Investigations were made at about forty localities in nearly all the states of Mexico north of the Isthmus of Tehuantepec. The route of travel was, in general, from Laredo to the City of Mexico, returning to El Paso, with side trips to Tampico, Veracruz, Oaxaca, Balsas, Uruápan, Manzanillo, Durango and other points. The following table shows the places visited, and the numbers of the specimens collected:[7]

TABLE II

LOCALITIES VISITED WHILE COLLECTING GRASSES

Locality	State	Approximate Altitude in Feet	Date	Field Numbers of the Specimens
1. Monterey	Nuevo León	1,500	July 6–9	5517–5578
2. Saltillo	Coahuila	5,000	" 10–14	5579–5652
3. San Luis Potosí	San Luis Potosí	6,300	" 15–18	5653–5711
4. Cárdenas	San Luis Potosí	3,000	" 19–20	5712–5778
5. Tampico	Tamaulipas	sea level	" 21	5779–5799
6. Querétaro	Querétaro	6,000	" 24–26	5802–5870
7. City of Mexico and vicinity	Distrito Federal	7,400	" 27–Aug. 2	5871–5960
8. Popo Park and Mt. Popocatepetl	México	7,600–14,000	Aug. 3–7	5961–6029
9. Tehuacán	Puebla	5,500	" 9–10	6030–6095
10. Oaxaca	Oaxaca	5,000	" 12–13	6096–6190
11. Tomellin	Oaxaca	2,000	" 14–15	6191–6249
12. Chalchicamula and Mt. Orizaba	Puebla	9,000–14,000	" 16–22	6250–6309
13. Orizaba	Veracruz	4,000	" 24–25	6310–6394
14. Córdoba	Veracruz	2,700	" 26–27	6395–6462
15. Esperanza	Puebla	8,500	" 28	6463–6504
16. San Marcos	Puebla	8,500	" 29	6505–6546
17. Veracruz	Veracruz	sea level	" 30–Sept. 1	6547–6556
18. Jalapa	Veracruz	4,600	Sept. 2–4	6587–6685
19. Pachuca	Hidalgo	8,000	" 6–7	6700–6770
20. Balsas	Guerrero	1,500	" 9	6772–6816
21. Cuernavaca	Morelos	4,500	" 10–11	6817–6885
22. Toluca	México	8,800	" 13	6886–6921
23. Acámbaro	Guanajuato	6,300	" 14	6924–6954
24. Uruápan	Michoacán	5,600	" 16	6957–7005
25. Manzanillo	Colima	sea level	" 19–20	7026–7046
26. Colima	Colima	1,500	" 21	7054–7110
27. Zapotlán and Nevada Peak	Jalisco	5,000–14,300	" 22–25	7111–7259
28. Guadalajara	Jalisco	6,100	" 27–29	7260–7386
29. Irapuato	Guanajuato	5,800	Oct. 1	7387–7438
30. Aguascalientes	Aguascalientes	6,300	" 2	7439–7494
31. Zacatecas	Zacatecas	7,500	" 3–4	7495–7537
32. Torreón	Coahuila	3,800	" 5	7538–7564
33. Durango	Durango	6,200	" 6–8	7565–7660
34 Torreón	Coahuila	3,800	" 9–10	7724–7729
35. Sanchez	Chihuahua	8,000	" 12	7661–7723
36. Miñaca	Chihuahua	7,000	" 13	7731–7769
37. Chihuahua	Chihuahua	4,600	" 14	7770–7803

[7] Missing numbers were collected at intermediate stations along the railroad.

Mt. Popocatepetl near the snow line. The tracks of cattle are seen in the sandy barrens. The white spots are the remains of the snow from a recent squall.

Epicampes macroura on Mt. Popocatepetl. The roots, obtained by prying up the large tussocks, are used in the manufacture of scrubbing brush.

Epicampes macroura. A single small cluster along a railway embankment at San Marcos, near Puebla. The flowers are in a dense spikelike inflorescence at the ends of the stems.

MT. POPOCATEPETL. The upper part of the mountain is bathed in clouds. At the lower edge of the cloud cap can be seen spurs descending from the snow fields. The sandy waste in the foreground is the home of *Festuca livida* a bunch grass about six inches high with large purple spikelets.

BOTANICAL AND AGRICULTURAL OBSERVATIONS

The observations here recorded are very elementary and emphasize unduly the group of plants which I was investigating, but they may be of interest because, though Mexico is our next-door nieghbor, its characteristics are unfamiliar to the average scientist who has not visited the country.

Floral Regions.—The great central plateau is an arid region, the flora of which is similar to that of southern Arizona, New Mexico and Texas. The flora of the Great Plains extends through Texas into the northeastern Mexican states, while the desert flora of southern Arizona extends into the states of Sonora and Chihuahua. The former flora is characterized especially by grasses; the latter especially by cactuses, agaves, yuccas, and various thorny shrubs. In a more or less modified form this desert flora is found on the plateau as far south as the state of Oaxaca. The upper part of the higher mountain ranges are usually wooded, the Sierra Madre range supporting extensive areas of coniferous forest. The rainfall in the mountain areas is greater than in the adjoining plains. The hills and the more isolated mountain ranges are usually rocky sterile wastes devoid of timber.

The low land along the eastern coast between the Gulf of Mexico and the foothills which mark the beginning of the as-

cent to the plateau is covered with a low forest which becomes toward the south a tropical jungle. The coastal plain of the Pacific coast is similar, but not so well marked, the hills in many places extending to the very coast. In Sonora the rainfall is not sufficient to support a forest. In all this low land, the *tierra caliente*, or hot country, the grasses are usually poorly represented both in species and individuals. At Veracruz the sandy plains immediately back of the coast are covered with an abundance of certain species of grasses, but in general such areas represent a very small proportion of the total.

The central plateau supports a desert flora, the density of which is largely dependent upon the amount and distribution of the rainfall. In the northern portion, north of the isohyet marking the limit of twenty inches annual precipitation, the grass flora is that of the desert regions of Arizona and New Mexico. The grasses are in bunches, known to stockmen as bunch-grasses, scattered over the surface of the mesas or of the lower hills. In the more arid places the bunches are at intervals of several feet, while in moist spots the bunches may be separated by only a few inches. Only under especially favorable conditions do the bunches approach one another to

ORIZABA FROM THE HILL LYING JUST TO THE WEST OF THE CITY.

Two fern fronds from the tropical jungle around Jalapa.

form a continuous mass or sod. Grasses with creeping rootstocks are not so common. In the northeastern states, where the Texas flora intrudes, may be found areas of sod formed by the buffalo-grass (*Bulbilis dactyloides*), curly mesquite (*Hilaria cenchroides*) and allied species. During and shortly after the rainy season the grasses of the mesa thrive and produce their flowers and seed. Later they become dry and brown, and retain life only in the crown and underground parts. The mesa grasses belong chiefly to the large genera, *Aristida, Bouteloua, Muhlenbergia, Sporobolus* and *Stipa*.

The region in which the grasses occupy the most important and conspicuous place is the slope from the central plateau to the coastal plain. This slope is characterized by an extremely irregular topography, being cut by numerous deep ravines, or *barrancas*. The rainfall increases rapidly toward the coastal plain, especially along the southeastern slope in the state of Veracruz. At the higher elevations there are extensive prairies with a rank growth of grass. Many of the hillsides and

the slopes of the deep barrancas are covered with grass. As the altitude decreases the proportion of forest-covered area increases and the grassy areas are confined to the hills. In this region the grasses are more tropical, and the genera *Andropogon, Panicum* and *Paspalum* are well represented.

On the upper slopes of the high mountains the grasses are often conspicuous. At moderate elevations, 9,000 to 11,000 feet, the large bunches of certain species of *Festuca* and *Epicampes* may cover large areas of treeless or sparsely wooded slopes. One species, *Epicampes macroura,* is used commercially, the strong roots furnishing material for coarse brushes. At the upper elevations, near or above the timber line, are found several kinds of tussock grasses belonging to the genera *Festuca, Deschampsia* and *Agrostis.* Upon the alpine summits, or the alpine belt below perpetual snow of the highest peaks, occur scattered dwarf alpine grasses belonging to the three genera just mentioned, together with certain species of *Poa, Calamagrostis* and *Trisetum.*

A LITTLE MOTHER CARRYING HER BROTHER WHO IS HALF AS LARGE AS SHE. The picture was snapped as she was trying to escape from the dreaded camera.

In the valleys upon the plateau agriculture is carried on with the aid of irrigation. Along the irrigation ditches may be found representatives of the native flora of the region even during the dry season when the plants upon the mesa are passing through their resting stage. The collections made by the writer in the arid northern portion of the plateau were chiefly from the vicinity of irrigation ditches or irrigated fields. In cultivated soil the species of grasses occurring are mostly weedy annuals, but along the ditches or the edges of the fields

A STREET IN ORIZABA, showing the characteristic Spanish architecture.

are found portions of the original vegetation which includes many species in flower, although the mesa may be brown and sere, presenting no grasses in flower.

Range Conditions.—Stock-raising is an important industry throughout the plateau. The grazing conditions are similar to those of the southwestern United States. Cultivated fields on that portion of the plateau north of about 22° latitude are confined to the vicinity of the water courses of the valleys that can be reached by irrigation ditches. Outside of such areas the agriculture of the country is confined chiefly to stock raising. Cattle, sheep and goats roam over the land, living upon the scattered herbage, the grazing radius being limited by the distance to water. Though grazing animals feed on a variety of plants, there is no doubt that the grasses form the most important part of the available forage. It not infre-

quently occurs that the grass vegetation has been almost entirely removed from an area by grazing animals, the original grass flora being preserved only within the protection of clumps of cactuses or other thorny plants, or upon inaccessible rocky cliffs.

The ranges include the highest mountains, and cattle were observed feeding far above timber line upon the snow-clad peaks of Orizaba and Popocatepetl, their tracks or evidences of grazing extending to snow-line.

Forage Crops.—So far as observed all forage that is cut is consumed green. By far the most important forage crop is corn or maize. This plant is grown primarily for the grain but large quantities are cut green for fodder. As the crop nears maturity a portion of the foliage may be stripped or the part of the stalk above the ear may be removed for forage. Much green feed is obtained by the poorer classes by pulling up weeds from cultivated fields or by cutting rank grass or weeds along the roadsides, the railroad right of way, or any other available source.

Alfalfa is commonly grown upon the plateau, but usually in comparatively small patches. One field was observed near Toluca which consisted of more than one hundred acres, the plants being grown in rows and cultivated. Throughout much of the plateau region the crop requires irrigation during the dry season. Ordinarily the alfalfa is sown broadcast and irrigated by the check system. The field is divided into several small plots, twenty to fifty feet square, by low ridges or dikes. The crop is cut by hand with sickles or knives, often close to the surface of the ground. The green alfalfa is placed in small heaps and later tied in bundles to be loaded on burros for delivery. Some of the larger ranches or haciendas are adopting modern methods and machinery.

At low altitudes, especially in the coastal plain, are cultivated Pará-grass and Guinea-grass (pronounced in Spanish, Guinay′-a). Pará-grass (*Panicum barbinode*) is cultivated chiefly for pasture. It produces a tangle of rootstocks and stolons which soon bind the soil into a firm sod. It is propagated by planting cuttings of the creeping stems.

Guinea-grass (*Panicum maximum*) is a perennial rootstock-bearing bunch-grass, cultivated chiefly for green forage. It grows to a height of five to eight feet or even more. The grass is propagated by planting pieces of the crown, or the creeping rootstocks. When growing isolated the stems may be more or less decumbent, but under field conditions the growth is upright.

EDUCATIONAL PUBLICITY

By Professor ULYSSES G. WEATHERLY
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THE rapid growth of attendance and equipment at American universities in the quarter century since 1890 has necessitated a readjustment of educational methods and a sweeping revaluation of educational ideals. Perhaps nowhere else in the whole range of social activities has occurred a more conscientious attempt to realize what Nietzsche calls a transvaluation of values. The college curriculum of the last generation was a fair expression of the mid-Victorian intellectual attitude. Whatever valid objections are now to be raised against it are founded on the fact, not that it was fundamentally unsound in principle, for on the whole it met vital needs and met them adequately, but rather that it virtually ignored large sections of human experience which this age has come to consider important. Particularly did it fail to include in proper measure the field of modern science and the wide range of vocational techniques, two sets of interests which transfer the center of attention from subjective to objective reality. Because of the magnitude and complexity of these interests the task of making a revaluation which should properly place them in the educational system has been a tremendous one, and furthermore it has been thrust on the universities rather suddenly. It is only within the last three decades that economic transformation has begun to very profoundly affect the structure of American society. That the lower grades of education as well as the universities are still in a stage of transition is evidenced by the chaotic situation in vocational education and by the unsettled curriculum of the high school.

That the success of the universities in shaping themselves to these new conditions should have been uneven is not to be wondered at. While grappling with intricate problems and honestly trying to seize a multitude of novel opportunities they have botched the job in some instances and achieved brilliant success in others. Higher education has still to get its bearings in an environment as yet largely alien. It has thus far neither accomplished a masterful evaluation of all its new materials nor successfully articulated them with the old. And

the end is not yet. Every year new undertakings and new applications of effort are brought to its attention. New types of students, also, hitherto unknown to academic circles, crowd university halls. Whether this irruption be regarded as a barbarian invasion or as the opening of a new world of opportunity, the fact remains that the traditional standards of academic life are gone for good and all.

A corollary of the new student types is a radically changed body of alumni. The phenomenal increase in numbers has brought it about that a considerable majority of living alumni are still comparatively young. They are pervaded by the spirit of this age of economic and educational upheaval rather than the static ideals of an older college era. Whereas the colleges used to train men primarily for the so-called learned professions, the present university body is large chiefly by reason of the throngs who expect to enter technical or business careers. Thus in 1797 forty-two per cent. of the Yale graduates became lawyers, thirty-nine per cent. clergymen, eight per cent. physicians, and only six per cent. entered business. Of members of the classes in the decade ending 1908 twenty-four per cent. became lawyers, five and one half per cent. physicians and three per cent. clergymen, while forty per cent. entered business. In 1908 a study was made of the occupational distribution of former students of Oberlin, an institution which has always had a strong religious bent and which was a pioneer in coeducation. It was found that but eleven per cent. were ministers or missionaries, and twenty-four per cent. were in business. Of the thirty-two thousand persons who have ever been connected with the University of Illinois, one of the largest but also one of the youngest state institutions of the Middle West, nine per cent. are now engaged in some kind of business, nine per cent. in engineering and eight per cent. in agriculture, while less than four per cent. are lawyers, one per cent. are physicians and less than three tenths of one per cent. are clergymen. Only eighty-three persons belong to the last-named class, which is exceeded in numbers by accountants and musicians.

A group of men whose interests and outlooks are dominated by the spirit of acquisitive business would naturally wish to see the standards to which they are habituated prevail in academic management. The scholar's leisurely indifference to proximate results and devotion to ultimate truth are irksome to minds accustomed to evaluate an enterprise by the amount of "pep" it exhibits and by its capacity for "punch." In proportion as education has assumed the function of preparing for

acquisitive vocations, it has itself become assimilated to the business ideal. Now two prime elements of present-day business are the competitive principle and the cult of bigness. To the business man success means the mastery of his field, which in turn implies beating his competitors. The commercial mind has little comprehension of or respect for an enterprise devoid of the fighting spirit. Casual observers, whether native or foreign, who think they perceive in dollar-hunting the sole incentive of American business mistake a symptom for the fundamental motive. The joy of battle is the lure, as it is the guerdon, of business activity.

Generous and dynamic loyalty which an institution is able to command from its alumni, while one of its richest assets, is at the same time liable to become a source of embarrassment unless turned to proper ends. If it aspire to excellence of ideal and achievement it is a source of real strength; if it expend itself in good-natured ambition for material prosperity it is at least useful; if it stop at pugnacious eagerness to overtop pet rivals in athletic or social prestige, it becomes a thing to be accepted with such patient endurance as can be mustered. In any case the alumni spirit is certain to be a potent factor in determining the trend of university policy. The preponderance of business interests tends to throw the emphasis increasingly on mere bigness. Just as a commercial concern which is unable to exhibit an annual increment in its volume of business is adjudged moribund, so the institution which does not, with each recurring autumn, report the largest freshman class in its history is branded as an academic lame duck. Growing assimilation to business standards is also tending, through selective fitness, to shift the qualities of administrative leadership from those of the educational statesman to those of the captain of industry accustomed to the problems of corporation management.

Still another corollary of the commercial trend is an anti-intellectual pose within the university itself. It may not be particularly surprising, although it is certainly significant, that a revulsion from the rarefied intellectual ideal should manifest itself among present generations of students in the guise of repugnance to "high-brow stuff" and dogged insistence that culture as an educational *motif* is played out. Vastly more significant is a somewhat similar trend among university teachers. Some part of this arises from a natural reaction against the extreme form of the old ideal, some part from an aspiration to get into closer touch with reality. The Zeitgeist

has decreed that reality is to be interpreted in terms of utility, which in education connotes vocational technique. But a more tangible element is the growing preponderance in the larger university faculties of men connected with technical and professional education. The question at this point is, of course, not one of the comparative worth of vocational and cultural disciplines, still less is it one of scholarly proficiency. All that is implied is that the old academic group type no longer exists. The ancient ideal of sheer intellectual excellence and beauty of spirit has been profoundly weakened even among its traditional exponents by the vocational drift.

Little penetration is required to perceive that educational tendencies pretty accurately reflect social changes. To say that education has shifted from the classical-cultural to the industrial type is to intimate that society itself has undergone a radical economic transformation. The characteristic elements of this change are outgrowths of the eighteenth century Industrial Revolution, now finding somewhat belated expression in America in the current social readjustment. Two of its outstanding features, the money economy and the machine-production economy, have made possible an almost incredible expansion of productive capacity which has slowly shifted the social center of gravity from the use of goods to their production. By far the larger part of the social resources are thus shunted toward the productive process. The result is a one-sided valuation of functions which has thrown our whole modern life out of gear, by so thoroughly absorbing our faculties in production that appetite turns to the process rather than the product. No corresponding elaboration of technique has occurred in the field of consumption. The contemporary world is immensely more proficient and more interested in creating goods than in using them intelligently.

Production is primarily competitive and dynamic, consumption emulative and static. The one develops, under modern conditions, a constantly improving technique, while the other changes but slowly. Production uses the social machinery freely and thus reacts directly on society; consumption pertains chiefly to the individual or small group and affects the social machinery but little. Now, the classical type of education, by which, of course, is not meant any particular set of studies but their fundamental purpose, is directed toward the promotion of appreciation and valuation, which are the basic elements of consumption. It has thus, like consumption, suffered a depression coincident with the overlordship of the productive

interest. In addition it has had to bear the imputation that it is a mere luxury, that it centers on individual excellence rather than social worth, and that it breeds a culture caste inconsistent with democratic ideals. This latter indictment was never sound in logic, and in practise is true only to the extent that in an over-industrialized society the materials of culture are not socialized to the same degree as are productive agencies. A social readjustment in the interest of balancing-up the consumption technique will go far toward wiping out whatever stigma now attaches to cultural ideals. For after all culture is essentially social. Although beauty may possibly be its own excuse, no one has ever seriously contended that intellectual excellence can validate its existence except as it ministers to the unity and solidarity of the general life.

Somewhat distinct from the industrial tendency, which is of external origin, is a form of revolt against classicism entirely from within. Any classical system, whether of art, music, literature or education, sooner or later reaches a stage where further increments of achievement must be small because its larger potentialities have already been exploited. There is thenceforth little outlet for surplus energy. Original creative spirits will at this point break away into those revolutionary innovations out of which new systems arise. From such a revolt in education in the second half of the nineteenth century came the influences which have carried into the universities their scientifice and professional schools. That this innovation was a genuine advance is now held by no one more firmly than the classicists themselves, who have profited by it to an extent that half a century ago would have been deemed incredible.

But there is a species of revolt which does not lead to original creation. It springs from the mere *ennui* of stagnation, and may manifest itself variously in a taste for the exotic or in mordant craving for extremes of novel or bizarre sensation like cacophonous music, or delirious art, or invertebrate drama. Among educators it is more likely to show in efforts to ease the irk of academic seclusion. Our modern system of minute specialization hems into a narrow range of activity minds which by their training are peculiarly fitted for elaborate self-expression. There is a steady pull toward a throwback to the unspecialized type of the average mind. Especially keen is the hunger for action, notably for those varieties of action which are most remote from the specialized routine. The old common-lands of knowledge and vocation have now

been pretty well fenced in, but the academic mind grudges to recognize artificial metes and bounds. Business undertakings, practical politics and radical popular movements, entirely apart from their technical content, have a peculiar fascination for university men. To this discontent with artificial limitation and to passion for adequate self-expression is to be assigned one source of the current academic radicalism. It is true that the cult of democracy in the universities has other roots, some of them even more elemental and permanent, but there is none which so much affects specific courses of action. At its best academic radicalism functions as a dynamic idealism such as moved Arnold Toynbee and his fellows at Oxford a generation ago. On a somewhat less exalted plane it is inspired by a hunger for opposites, as when men of cultivated leisure throw themselves into popular enthusiasms for pure love of novel experience. Men of this cast are not content, with Matthew Arnold, merely to "*see* life steadily and see it whole"; they would fain master life's action-content as well as its idea-content.

In such desire for broader self-expression, whether in the form of humanitarian zeal or individual gratification, the university extension movement also had one of its two sources. The scholarly instinct of workmanship is as yet imperfectly adjusted to the straitened technique of specialization. In a wider range of educational effort lurks the alluring promise of contact with a stimulating variety of people and activities. When the extension idea was first propounded in England, now more than sixty years ago, scholastic exclusiveness was still the rule. At both Oxford and Cambridge many classes of students were excluded by religious or other tests, nor was there anywhere adequate provision for the higher education of women. This was also before the day of free and general lower schools. In America these obstacles then existed in a much smaller degree, and to-day they exist hardly at all. Carrying the university to the people—the formula then popular—is not to be lightly dismissed as a grandiloquent phrase, for it holds a worthy and practical idea, although, like many another great idea at its inception, it fails to put things in proper perspective. It is now becoming clear that, apart from the rather limited number of persons who are prepared to profit by extra-mural work of university grade, the larger need is one which other educational concerns, and not the university, are best calculated to meet. General educational extension is verily demanded, and the universities deserve credit for some necessary

pioneering work in a field which they can not wholly or permanently occupy. As a mode of large-scale academic self-expression, however, the extension movement has turned out to be a Dead Sea apple in the hands of idealistic reformers.

While, therefore, the idea of universalizing educational opportunity is no romantic illusion but a very sound reality, and while the university for some time will probably hold a commanding though constantly diminishing share in it, to agencies outside of higher education must in the end fall most of the task of putting it into action. It is unfair to say that the original idea of extending the university itself has gone bankrupt; it is more accurate to say that, since most of the ends to which its originators looked forward are found to be better reached through other agencies, the name and form have been appropriated to ends which certainly were never contemplated by the first promoters. Despite the present overtaxing of academic capacities, the extension system has lately come to be used as a means of augmenting the volume of academic business. It is fair to say that this aspect of the subject may not in all cases have consciously influenced the welcome which the newer extension projects have received. One may find plenty of verifiable merits in the extension idea, but at the same time it does make a magic formula to insert in the plea for material support. For institutions dependent on private donations it offers a substantial basis of appeal to potentially benevolent wealth, combining as it does the claims of education and philanthropy. Publicly supported institutions, having to make their case with a larger and more miscellaneous group, accept the extension system as a quick and easy method of ocularly demonstrating their general and practical worth. Certain phases of extension work in the agricultural or engineering schools, and latterly also in the new colleges of commerce, can be shown to yield direct pecuniary returns to the state. Used as a sort of protective coloration these features shield or promote the general body of subjects which, by reason of their non-pecuniary character, have little popular appeal and would be accorded but grudging support.

For the opportunity which it offers to the limited number who are prepared to profit by work of university grade, and for the part it has played in quickening educational activity in general, the extension movement is entitled to generous recognition. On its miscellaneous activities which are based on the theory that there is or can be an easy road to higher learning a less favorable verdict must be rendered. It ought not to be

necessary to prove, although it is sometimes seriously denied, that sound learning can never, by any process of softening, be made other than a rigorous discipline. Any attempt to offer it on other conditions is both specious and conducive to mental and moral slovenliness. Pushing people indiscriminately into higher education without regard to taste or capacity will send into the universities, as it has to some extent already done, many who do not even under the most liberal interpretation belong there. Exactly because of its superlative worth higher educational opportunity is wasted on those whom the urge of intellectual hunger or militant ambition does not propel to meet it. The plea that extension activities may possibly stimulate this hunger is sound so long, and only so long, as the lower schools fail, by reason of their inefficiency, to search out and quicken the latent talents scattered through all levels of society.

A form of extra-mural activity which has wide present vogue is the direct participation of universities in public service. The Wisconsin Idea, now somewhat bedraggled, has been extensively copied near at hand and still more admired at a distance. There can surely be no controversy about the desirability of higher education's reacting dynamically on industrial and social life. The only question is as to methods of making the results of science available in and for social action. It happens that in the United States as contrasted with England of the last generation most of the men who are devoted to pure science are connected with universities. Any influence which deflects them from research toward the application of science to the detailed processes of industry or administration weakens their capacity for original work and correspondingly lessens their ultimate social value. The outside pressure on university experts is always strong and in the state universities it is almost irresistible. To this cause may probably be attributed the undeniable poverty of scientific achievement which Americans have to lament in the same breath which glorifies our more material achievement. A historian of music has remarked that Italy is a land of singing but not of music. If America can be called a land of schools rather than scholarship the reason may possibly lie in our requiring science to earn its daily bread in the mill instead of the laboratory or study.

If the idea that the process of higher education may be made easy is fallacious, the assumption that there is a facile and burdenless mode of supporting it is no less misleading. As learning is a process calling for both talent and boundless application, so the task of maintaining it is one that society

must assume in serious and understanding mood. To inculcate the idea that the university, or for that matter any other educational venture, may show immediate profit in a pecuniary sense is to misinterpret its intrinsic purpose. As well maintain that a city park or a public library should yield a profit. Nobody denies that these are profitable undertakings, and, equally, nobody misunderstands why they are so. The university is not so fortunate in the judgments accorded to it.

Whatever may be the ultimate status of the extension system as a whole, some of its miscellaneous undertakings which are now utilized chiefly for publicity purposes can have no permanent standing in their present form. Holding conferences on matters under popular discussion, exploiting the more appealing features of the uplift movement, or assuming the rôle of lion-provider to the curious public, are admittedly effective methods of keeping an institution in the spot-light. They may even be shown to be useful functions which under proper control have legitimate educational value, but they deserve no place among serious academic interests so long as they are tinged with the spirit of vaudeville or dominated by the ideals of educational impressionism. Essentially different is, or ought to be, the position of the summer session. At Oxford first, and a little later at Cambridge, the summer meeting was an integral part of the extension plan, and it has shared the vicissitudes of the extension system. The American summer session is an appendix of regular intra-mural activity, although it has always partaken of some of the features and objects of the extension system. Inaugurated to meet the needs of exceptionally serious types of students, it has the additional merit of keeping the educational plant in productive use during a season when it formerly was stark idle. The students who avail themselves of it are predominantly of a class that require few tawdry attractions. By them, if by any, the institution may hope to have work judged on its intrinsic merits. If there is, here and there, a growing tendency to turn the summer session into an educational Coney Island, it must be attributed to influences that originate primarily on the side of the university itself and not on the side of the students or in their needs.

The course of recent educational history has demonstrated that university expansion has been stretched almost to the breaking point. The inexorable alternative is now presented of continuing with the policy of scatter and smatter, or of concentrating on clearly delimited undertakings which can be effi-

ciently managed within the limits of available resources. The choice of field ought not to be a difficult one. Beneath all specialized vocations and techniques are the bodies of fundamental knowledge which make them possible. Of such knowledge the university is the clearly designated exponent, for here it has no competitor. It obviously can not hope to find place in its curriculum for any considerable number of the strictly vocational interests that are clamoring for educational recognition. These must be provided for in special schools. That basic knowledge which must constitute its staple product is what John Stuart Mill had in mind when he said:

> The state of knowledge at any time is the limit of the industrial improvements possible at that time; and the progress of industry must follow, and depend on, the progress of knowledge. The same thing may be shown to be true, though it is not quite so obvious, of the progress of the fine arts.

Two perils of the scatter-and-smatter policy stand out conspicuously. The first is the crude fact of fiscal and material unwieldiness. The second is the crippling of scientific achievement through distraction and dissipation of effort. Expert scholarship is little likely to prosper where academic specialists are required to be concerned with a multiplicity of extraneous interests, or where any considerable share of their attention must be given to immediately utilitarian concerns. Genuine scholars who have the capacity for original work are not only within their rights, but are performing their highest duty both to their institutions and to science, in resolutely refusing to be drawn away from productive work to promote undertakings in the interest of ephemeral publicity.

Those forms of public activity which look to increase of size and numbers have all the less excuse at present because many of the institutions most active in publicity ventures are already becoming unwieldily large. In 1914 twenty-eight universities of standard grade had over four thousand students, and seven had over six thousand. At the same time fourteen enjoyed an annual income of more than one million dollars, and nine had more than two million dollars. Even commercial enterprises may reach a point beyond which additional business becomes a drawback and the principle of diminishing returns begins to operate. Up to a certain limit there is a genuine educational advantage in a large student body, just as there is in variety of student types. Inordinate numbers, on the other hand, are an impediment to effective teaching, and weaken that organic group coherence which is so fruitful a

factor of institutional life. Moreover, it is a notable fact that over-population of the universities, which enforces mass treatment, has developed in exactly that period when the value of individualizing instruction has come to be most distinctly recognized.

As the larger institutions approach the limit of manageable numbers the wisdom of selecting the student body by qualitative instead of quantitative standards becomes increasingly plain. To be satisfied with docile mediocrity is to miss the transcendent educational opportunity. That mediocrity tends to be the outcome where numbers are taken as the ideal was admirably shown by President Schurman of Cornell in his annual report for 1910:

> The colleges and universities of the United States address themselves to the average student, and in a democracy there will always be a strong feeling, which is also perfectly natural and just, that higher education should be open to all the boys and girls of the country who are able to pass the requisite examinations. The practise of this theory necessarily tends to make the college or university of the country revolve about the *average* student with a strong pull in the direction of mediocrity. But the student of superior endowments is apt to be sacrificed to the general average. Now it might be possible to retain the advantage of universal higher education for all who are qualified to enjoy it without sacrificing those youth of superior or extraordinary endowments among whom will always be found the men who advance civilization, who move the world forward in the course of progress. Those glorious "sports of nature" (to apply Darwin's botanical phrase to corresponding human beings) have in their unique endowments the possibility of higher things for their species, provided only it is developed by favorable environment and suitable training. Why might not Cornell University become the peculiar nursery of such promising spirits? A seminary for the aristocracy of talent would be the highest and noblest institution in the world. And no other service to democracy could compare with this; for to form the mind and the character of one man of marked talent, not to say genius, would be worth more to the community which he would serve than the routine training of hundreds of average undergraduates.

Isolation, selection and concentration are the urgent calls on present educational statesmanship; isolation from the routine details of vocational or administrative processes; selection of the most productive lines of effort and the most promising students; concentration of resources on the fields and students so chosen. Such a program seems at first blush to smack of detached and self-centered exclusiveness. But, rightly understood, academic isolation has nothing in common with ivy-clad cloistral seclusion. Between the serene aloofness of the cloister and the vociferous publicity of the market place is a zone of quiet industry where the best of the world's goods are created. Here the expert scholar takes his place

with others of the labor group. Perhaps more than any other he has preserved the ancient pride of craftsmanship. If he is a little finicky about the quality of his work it is because he expects to have that work judged by fellow-craftsmen who know good product when they see it.

Something was said before about the pathological reactions of specialization. Granting that a too narrow range of activity breeds a natural discontent, it is still true that only by giving himself unreservedly to his chosen work can the scholar be either permanently satisfied or really useful. The academic scholar's objections to garish publicity may be compressed into two. Through it he is distracted from congenial work, and where it is insisted on he is forced to advertise by means of his poorer rather than his better achievement. It ought normally to be one of the peculiarly fine attractions of the academic career that men may work at what they can do best, and that they shall be required to turn out only work of a quality which approaches as nearly as is humanly possible their own ideal of excellence. Herein the artist or the literary man are often more hampered, in that they may have to consider the exigencies of the commercial market upon which their livelihood depends. Scholars must, indeed, reconcile themselves to falling a little short of Goethe's transcendental ideal,

> Uns vom Halben zu entwöhnen,
> Und im Ganzen, Guten, Schönen
> Resolut zu leben,

but unless overborne by importunate outside pressure they may fairly aspire to dodge Carlyle's growling malediction on cheap and nasty products:

> No good man did, or ever should, encourage cheapness at the ruinous expense of unfitness, which is always infidelity, and dishonorable to a man. . . . They are not permitted to encourage, patronize or in any way countenance the making, weaving or acting Hypocrisy in this world.

Forty years ago Johns Hopkins began the publication of scientific series wherein appeared such results of scholarly research as might not have been commercially profitable if published through the ordinary channels. More than thirty institutions have since followed this lead with series of varying grades of excellence. It is true that President Gilman in his later years expressed a fear that the Hopkins example has not proved a wholly fortunate one in that too many series have been started, but the fact remains that, besides their service in making scientific results more generally available, these series have appreciably stimulated research. In this case the univer-

sities are turning out a product which is both characteristic and dignified.

Outside of this purely scientific activity, designed for a public composed chiefly of scholars, there are many features of academic life which, because they have legitimate and general news value, are calculated to bring the institution to public attention in a truly representative light. By holding resolutely to these the amount of publicity would certainly be lessened, but it would be of a quality calling for no apology. Self-respect is the only sure and permanent guarantee of public respect. The difficulty about special feature stories and similar methods of attracting public attention is that their appeal is made through non-essentials, and the interest they arouse must be continuously prodded with fresh stimuli. Like the less solid type of journalism, educational self-exploitation dare not for a moment relax for fear of bankrupting interest.

Of course it is not within a university's power to control the whole output of its news or to greatly modify public demand for the more trivial sorts, for news has become a commodity with market value. What is possible in the way of regulation is the withholding of official sanction from those news-making enterprises which do not fairly represent what the university stands for. Intercollegiate athletics offers a case in point. Who, for example, is responsible for the fact that the press gives three inches to an intercollegiate debate or a scientific congress and three columns to a football game? The university casts the blame on the press, the press passes it over to the public, the public professes to believe that the university wants this kind of advertising, and so the vicious triangle is completed. No reputable institution does in fact rank athletic prowess on a par with, let us say, love of good literature, but very few have seriously attempted to do away with the public's nonchalant skepticism on this point by formally annexing and rigorously governing this troublesome border province of Philistia.

Even such intrinsically wholesome publicity as comes through publication of scholarly work does not entirely escape the danger of deterioration. The quantitative measure of publication, as also the frequency measure, is in itself hardly an accurate test of academic fitness. To appoint or promote a man solely on the quantity theory is, for one thing, to discount teaching efficiency, which even to-day may still be held to take high if not premier rank as an educational asset. That the publication test is as a matter of fact responsible both for impoverished teaching and for much shoddy and immature work

getting to press is a fact of academic life hardly to be denied. The man who must "advertise his university" by constantly appearing in publishers' announcements will naturally turn out work which he knows to be short of his best, but which he dare not withhold. Education has occasionally, and not always to its advantage, taken lessons from business; here it has strangely ignored a pertinent example. Hasty production, and quick marketing with a rapid turnover, are sometimes bad business policy. Some goods require a deliberate process of production and some acquire augmented value through storing and seasoning.

In both purpose and method educational publicity must differ from commercial advertising because the central purpose of education is impartive and not acquisitive. Unvexed by the need of immediate gain, the educational process can hold over its accounting until such time as the larger audit of social progress is made. Unless it renounce its high mission of preparing and storing the instruments of progress the university must often be an apostle of the useless. It must at times become the home of unpopular causes and the warehouse of unmarketable goods, for science is usually born before its time so far as market values are concerned. To it falls the task, hardest of all for egoistic human nature to accept, of laying subterraneous foundations upon which in after time will rest visible structures in which it can claim no conspicuous share of credit.

Despite clamant protests from the commercial mind on the one side and pearly visions of the utopian cloud-treader on the other, the university must remain frankly academic. It must do this because thus alone can it save itself from disintegration and conserve its organic efficiency for the service of society. It is possible to conceive of an educational agency which might devote itself wholly to promiscuous public activities, but it is not easy to imagine such an institution as long retaining capacity for worthy scientific achievement. Once for all higher education must choose its contacts and outlooks, which are not at all the contacts and outlooks of the general store or mail-order house. As the present chaotic situation in higher education gradually clears up many undertakings now stridently urged for its acceptance will doubtless be found unable to show cause, and others will have been definitely assigned elsewhere. Nor is it especially likely that present refusal to go over to the Philistines will in the long run turn out to have been either very perilous or very unprofitable, for the mass of men do yet instinctively respect learning and wish it prosperity.

MOTIVES FOR THE CULTIVATION OF MATHEMATICS

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THE fundamental motives for its cultivation mathematics shares with the other sciences; for they and it are equally creations of the mind and derive their characteristic qualities from the mind, subject to varying color due to the differing materials. Motives which are special to the science of mathematics, if they exist, are less fundamental and are personal rather than general in their nature. In the light of the subject matter of mathematics the basic motives may exhibit a different color or a different mutual relation from that to be observed in the light of another particular discipline; and this variation may be worthy of special consideration. In a particular age or country the general motives may operate in unbalanced proportion so that an analysis of the situation may reveal improper tendencies which demand correction. It is for the purpose of ascertaining what changes, if any, are desirable in the distribution of motive as it now operates in the cultivation of mathematics in America that the considerations of this essay are presented.

It may be possible to classify motives into logically distinct groups so that there are no omissions and no overlappings; but it serves better our purpose to divide them into classes not mutually exclusive, classes among which there are vital connections analogous to those among the various parts of a living organism. It appears also that this is the better way to exhibit the science in its true aspect as a thing of life, growing under the action of ever-varying forces and impulses.

Probably the most fundamental impulse for the advancement of knowledge is that which grows out of the pursuit of truth for truth's sake. We are fundamentally so constituted that we delight in knowing for the sake of knowing. It is hard to describe this motive, or even to conceive it, in other than a vague way. It is our most abstract and our most general motive. It actuates most powerfully our choicest spirits, moving them sometimes with a fervor akin to that of religion. A marvelous curiosity to know creates a longing which can be satisfied only by knowledge. It projects itself into the unknown and leads the researcher in ways yet untrodden to a goal which

can not be foreseen. At the outer boundary line of knowledge, faint glimmerings may be detected in the darkness of ignorance beyond. What beckons us forth we do not know. Whether it can bring us any good we have no means of foretelling. It may lead us to a tragical something which will make it necessary for us, in much pain, to cast away some of our most cherished prejudices. But, whatever lies beyond in that which is concealed from our present vision,

> We work with this assurance clear,
> To cover up a truth for fear
> Can never be the wisest way;
> By every power of thoughtful mind
> We strive a proper means to find
> To bring it to the light of day.

Delight in the beauty of truth is a central incentive to its study and creation; and this operates with a unique and peculiar power in the cultivation of mathematics. In some respects its beauties are peculiar to itself and require the trained mind to perceive them, just as the deeper beauties of music (for instance) are perceived only by the practised ear of the musician. A much larger proportion of the excellencies of mathematical truth can be enjoyed by cultivated people in general than is usually supposed; but we still lack the exposition suitable to make this manifest. Both for the individual mathematician and for mankind at large a second fundamental motive for the cultivation of mathematics is that which grows out of the pursuit of high esthetic interests.

The leading characteristic of man is the power to think. There is nothing of higher esthetic interest than to determine whether we can think consistently. This fundamental question can be answered in the affirmative only by exhibiting the result of consistent thinking. The existence of mathematics gives the spirit of man leave to believe in itself, since here admittedly is a body of consistent thought maintaining itself for generations and even for millenniums.

But man is not all spirit. We can not live by intellectual delight alone. We have to get around in a world which has trees and stones and mountains and rivers, and shifting currents of force, and even living things which dispute with us the possession of the earth or are used by us for food or beasts of burden. Many of these opposing forces are physically far stronger than we. If we are to control them it must be through a superior knowledge of them and of our common surroundings. This knowledge is necessary to our welfare. Thus as a third fundamental motive for the cultivation of mathematics we have that

which grows out of the pursuit of means for interpreting and understanding our environment.

It is obvious that a single piece of mathematical work may be undertaken from considerations arising at once from two or from all of these three fundamental motives. There may be involved simultaneously the pursuit of means for interpreting and understanding our environment, the pursuit of high esthetic interests, and the pursuit of truth for truth's sake. But it seems that there is no other motive of fundamental importance which is not included in these, either separately or conjointly. That which finds its place here least naturally, perhaps, is the play motive which has certainly operated with considerable force among a few persons who have cultivated mathematics in the spirit of amateurs. But so far as a thing of this sort has been a fundamental motive in the general development of mathematics it may be associated with the delight arising from esthetic considerations or from the desire to know merely for the sake of knowing.

Even such an ideal motive as that arising out of the pursuit of truth for truth's sake has in it elements of danger, owing partly to the lack of clear definition of what is involved in it. It is easy to give it glibly as one's fundamental motive and so conceal from oneself a lack of thought on the matter or the lack of deep reality or genuine sincerity in one's motives. On account of its vagueness it may give rise to a sort of mysticism which does not consort well with scientific ideals. It runs the risk of becoming a fetish, an object of excessive devotion, and of drawing the veil over necessary distinctions in the values of truths. A catalogue of all the truths in the universe would probably be useless to limited beings like ourselves. The totality is so vast that we can not comprehend it or get about among its parts. We need some means of ascertaining what truths signify something for us, as we should otherwise be lost in the maze of all that is true and be unable to extract what is of value to us. In the pursuit of truth merely for truth's sake there is danger of giving attention alike to what properly concerns us and to what is without distinct relation to any of our needs. We require other motives to operate in the way of helping to direct our activities.

The demand for simplicity and elegance in the pursuit of esthetic interests in science may tend to render labor effeminate. Mathematicians must attack difficult problems with the zest of red-blooded vitality. They must not be repelled by complexities and inelegancies. The problem which is confronted in the search for truth must be solved, even though it be by tedious

means and with results hard to understand. To be sure, "a thing of beauty is a joy for ever;" but nothing is a thing of beauty which is merely so. That beauty is not permanent which is its own entire excuse for being. In scientific truth there is a need of sincerity and high purpose back of the creation of anything of beauty. To pursue truth merely and solely for the sake of esthetic delight tends to induce in one an admiration for the tinsels of knowledge and a joy in its more superficial elements. The greatest delight in the beauty of truth flows from its unfolding as an incident to the creation of values of profound import to mankind.

Gross utilitarianism is the obvious danger which arises from the pursuit of means for interpreting and understanding our environment. If we start out to create truth for the sake of its applications we take a one-sided and narrow view of it. By circumscribing our vision we fail to see the connection of related parts and our progress is soon brought to an end. Nature does not yield her secrets to him who seeks them to supply his immediate grosser needs; she rewards only a more idealistic purpose.

Worse than any of these dangers incident to an improper emphasis on the general motives is that arising in the case of an individual or a nation from false or selfish motives. From the ore of thought important truth can usually be extracted only under the heat of a glowing zeal, when the mind is surcharged with that determination which arises from strongly motivated activity. Work which proceeds not at white heat is coldly done and possesses not the fire of vitality. The mind can be brought into this fit attitude and activity only by means which are in accordance with its fundamental ways of working. A motive growing out of the desire for selfish values inspires no such state. Only minor results may be achieved under such a spur to activity. The young researcher who looks forward to a career of useful discovery should regard the cultivation of high motives in his own mind as one of his primary and most important duties. If he is not already moved by the higher considerations, there is little hope for him; if these now operate powerfully in his thought, let him seek means to develop them more fully, let him meditate upon the things of higher importance and more profound value so that these shall ever renew and build up in him ideals of the nobler sort. One can not successfully woo the science of mathematics (or any other science) except under the inspiration of high motives. She refuses to consort with sordid aims. She can be happy only with him of high ideals who cherishes her nobler qualities; and only to him will she yield her increase for the blessing of mankind.

Over against the dangers arising from an unbalanced emphasis on the fundamental motives are the peculiar advantages due to those activities which are inspired primarily by each of them separately. In pursuing truth for truth's sake we solve hard questions by the best methods we may; but we solve them, or else we keep them before us as an ever-present incentive to the creation of new methods of conquest and power. Difficulty never turns us aside, except temporarily while we seek new means of progress or investigate adjacent fields. The absence of apparent esthetic satisfactions is no bar. If we can not find the truth which delights us with its elegance and beauty we will ascertain the best possible. We shall brood over its incompleteness until we find a way of bringing it to perfection. If the matter connects with things which appear to us vital we shall pursue it to the end regardless of practical utility of any sort. An inner spring, a necessity of our being, impels us in this direction. We are fortified in the desire to follow up our inclination here by the observation that our predecessors in laboring under a like impulse have often found results necessary to the realization of other desired ends. The unknown is too mysterious to be charted in advance. For the best means of penetrating it we must trust largely to our blind instincts, modified perhaps by past experience but still maintaining their central characteristics. In this way we not only acquire new truth, but we also develop new methods of discovery, the most elusive thing in scientific progress. A method discovered in one field under the fire of a blazing zeal enables us to surmount elsewhere other difficulties of more immediate concern, perhaps, but lacking an element which brings us in the consideration of them to the highest state of concentration and creative activity.

In pursuing esthetic satisfactions we create a beautiful theory for the sake of our delight in it, as in the case of the theory of numbers or of abstract groups. Working in such fields with the simpler elements of mathematical thought we make progress of a sort not at first possible with the more complex materials. We bring the theory to a higher state of perfection; there are fewer lacunæ; the connections of the various parts are exhibited with clarity; we have a sense of having seen to the root of the matter and having understood it in its basic characteristics. The theory thus developed becomes an ideal in the light of which we get a new conception of what should be attained in other fields where the labor and the difficulty are greater. Results in one field of mathematics may thus become of great value in a totally different range of mathematical ideas or even in other disciplines altogether. Moreover, when such

progress is attained we often find that the tools employed in bringing it about are sufficient for dealing with more difficult matters, so that the one completed theory furnishes us not only the ideal, but also the means for further valuable progress.

A characteristic delight in mathematical truth is that which arises from economy of thought realized through the creation of general theories. When we develop the consequences of a set of broad hypotheses we find that our results, which are attained by a single effort, have applications at once in many directions. Thus we see the common elements of diverse matters and are able to contemplate them as parts of a single general theory pleasing for its elegance and comprehensiveness.

Whether we like it or not, the evolution of humanity is a part of the cosmic process. Investigation shows that it has been so in the past. All the means by which we explain development point to the conclusion that it will remain so in the future. Since we are a part of the cosmic process, our greatest good comes with our best understanding of it. Our direct and unaided intuition does not lead us far toward comprehending the complexity of our environment. We have not the power to see directly into the explanation of things or even to devise representations of phenomena. We must seek means to assist our weakness in overcoming the difficulties of understanding. We can afford to omit none which yields, or which promises to yield, useful assistance.

Mathematics has shown itself a valuable tool in the interpretation of phenomena. It has been successful to a marked degree. It is marvelous what sorts of things come within its scope and what connections it exhibits among them, as, for instance, in celestial mechanics, rational mechanics, kinetic theory of matter, and the theory of electricity and magnetism, to mention only a few. Through the help of mathematics we gain an increased control over nature, to our comfort and perhaps to our happiness. Through this we are able to supply our bodily wants more readily and therefore have greater freedom for meditation on the deeper things of existence—those things which we have not yet been able to bring under the domain of exact science, however vital they are to our general and to our individual development.

This contact with nature gives mathematics itself a fresh strength and a changed direction. Excursions into the domain of applications enrich the science with new conceptions, new problems and new methods. This is borne out by the history of the past, both the remote and the more recent. It is especially noticeable in the creation of some of the most important

disciplines and in the activity of some of the most renowned mathematicians.

It is instructive to consider the distribution of motive in the work of certain of the greatest mathematicians. We select a few from different ages and fields of mathematical activity and of varying temperament. The list of course might be greatly extended; in fact, this is done to some extent in our later consideration of certain specific topics. Those here chosen may perhaps be taken as representative of the class of mathematicians of leading importance.

We begin with Euclid. To what extent he was an original investigator is unknown; but he must have made important contributions, since otherwise his *Elements* would not so quickly have supplanted the work of his predecessors. He gave his writings a good form from the point of view of logical connection and also of pedagogical excellence. It is clear that he took delight in the beauty both of the content and of the form of his work and that he developed it primarily from the love of truth for its own sake. But his geometric postulates are what he believed to be the obvious properties of space, either of experience or of contemplation; and this part of his work may therefore be looked upon as a contribution to the study of that space in which all phenomena have their being. Still it is certain that our three general classes of motives did not operate in balanced proportion in actuating the work of Euclid, at least if we agree that the normal situation is that in which they should receive approximately equal emphasis.

Archimedes was probably the greatest mathematician of antiquity. He was inspired primarily by the love of pure science, rejoicing in the truth because it is the truth and feeling a certain contempt for the applications of truth in the way of supplying our grosser needs; and yet he was a great practical inventor and had a wide range of knowledge of phenomena, and frequently gained new strength by his contact with nature. He founded the theory of hydrostatics and contributed effectively to the initial development of mechanics and of astronomy, so that he is to be reckoned as an important figure in the history of applied mathematics even though it is true that his leading title to fame comes of his work in pure mathematics. In him we have another instance of contributions of high value associated with an unbalanced emphasis on the fundamental motives.

Fermat seems to have cultivated certain parts of mathematics for the pure love of their beauty. Probably he was hardly conscious of motive at all, since his activity was so nearly

spontaneous. He made important contributions and inspired great advances, primarily in the way of new impulses to certain isolated studies.

Newton was undoubtedly moved primarily by a desire to understand and interpret natural phenomena. To this motive therefore we owe his invention of the differential and integral calculus (shared with Leibniz), the founding of celestial mechanics and rational mechanics in general, and the consequent development of applied mathematics in many fields of science.

A very few individual men have stood out among their contemporaries as admittedly the greatest mathematicians of their respective ages and have had the good fortune to have this verdict sustained by later generations. Euler was one of these. His prodigious activity and the penetrating character of his ideas have been alike the admiration and the inspiration of his contemporaries and successors. He has touched almost every department of mathematical science and most modern subjects in mathematics (both pure and applied) are affected by one or more streams of influence from his genius. He was actuated by all three of our general motives. From his memoirs one may select typical cases of work actuated primarily by any one of our three classes of motives or any combination of them. Taken as a whole his work holds a just and balanced proportion among them. No man before him seems to have given so nearly equal emphasis to each of the three fundamental motives, and no one has ever maintained a more vital and vigorous enthusiasm enduring over so long a career of investigation. It is significant that this balance of emphasis was coupled with discoveries of the greatest range and magnitude and influence and importance.

The case of Gauss affords another instance where the three motives worked in proper proportion, and also another instance of one holding a place of preeminent importance and influence. He was inspired by the beauty of pure truth as exhibited, for instance, in the theory of numbers; he sought a deep and penetrating understanding of things for its own sake, as in his meditations on non-Euclidean geometry; he devoted much attention to the interpretation of natural phenomena, as in his study of electricity and magnetism. The range of his influence on the further development of mathematics has been as great as the variety of motive inspiring his work. He, as well as Euler, teaches us the value of balanced emphasis in motives, at least for those who are prime movers in the development of modern mathematical science.

Poincaré is the latest example of one to stand out definitely and admittedly as the greatest mathematician of his time. He

was actuated by all three motives in balanced proportion. He made fundamental contributions in many fields both of pure and of applied mathematics. No one can look at his work without seeing how he rejoiced in the beauty of truth. He has left on record a statement of his profound delight in science as the means of seeing, of knowing, and he has emphasized the fact that after all it is knowledge and insight alone which count. In the introduction to his first note on Fuchsian functions he says: "The aim which I propose . . . is to ascertain whether there exist analytic functions analogous to elliptic functions and suitable for the integration of linear differential equations with algebraic coefficients." It is known that his interest in differential equations was largely affected by their use in applied mathematics, so much so in fact that he was depressed when certain recent physical theories seemed to imply that differential equations are not so fundamental to the understanding of phenomena as he had supposed. Moved by the most profound motives and of the widest variety, operating over an extremely wide range of material, employing ideas of the most penetrating character, and applying his results in many directions, Poincaré stands out as the leading creator of mathematical truth in the past half century and one with few equals in the history of mankind.

Poincaré exhibited also a tendency, more marked in him perhaps than in any other mathematician, to consider a range of ideas which should probably receive increased attention owing to the growing complexity of modern mathematics (and science in general), namely, the tendency to analyze the elements of our progress in the light of broad philosophical principles. What we believe concerning the nature, the meaning, and the value of the truth with which we are concerned has a profound effect upon the operation in us of the motives for its creation.

If the illustrative cases which we have adduced are to be taken as typical of the best work in mathematics—and we have tried to make them so—they would seem to teach, among other things, that with the growth of mathematics there is a growing necessity for a proper distribution of motive in the work of the individual thinker if it is to maintain a place of preeminent importance in the development of the science. In the case of a nation or a people the same thing appears to be true in general. Early in its history a science may develop in parts in a one-sided and unproportioned way. But when it attains to maturity and each new advance must rest on a large body of results previously derived it is of increasing importance that a balanced distribution of motive be maintained.

It is instructive also to examine the distribution of motive in some of the most important subjects of recent progress, following the development without reference to the individuals by whom it has been brought about. To me it appears that the greatest recent advances have been made in the domain of analysis—in territory either directly belonging to it or closely connected with it by association—and that in this field are likely to arise our most fruitful investigations in the near future. Here we have a wealth of outstanding problems of broad character and of far-reaching importance. If it is so in algebra or in geometry, I am not aware of what these problems are. For this reason I have chosen the following illustrative topics primarily from the field of analysis.

Nothing is more characteristic of the modern element of rigor in mathematics than the theory of point sets. Viewed in its relatively completed state, it seems to be well removed from all considerations pertaining to an interpretation or understanding of our environment. In some aspects it seems almost to be merely a set of logical exercises created for themselves. In every way it has the appearance of a body of truth developed for its own sake under the impulsion of a desire to see the inner meanings and beauties of things where the intuition is in a large measure helpless. But a study of the chain of causes which led to the development of this theory carries us back to Fourier's investigations in the distribution and flow of heat and the fundamental function-theoretic questions which were brought into prominence in the discussion of his work. Thus we find all three classes of motives operative here, though one of them appears in a concealed form which is brought to light only by an examination of the history of the subject.

The extraordinary activity manifested a few years ago in the rapid development of the theory of integral equations was brought about by the conjunction of all of our classes of motives. The theory is elegant, and the body of truth developed is pleasing in its character and in its relative independence as a unit together with the many connections between it and other disciplines, and it has numerous direct applications to the interpretation of physical phenomena.

Many influences have operated to compel mathematicians to enter upon a study of functions involving an infinite number of variables. Our most simple means of representing general classes of functions of a single variable bring us to consider at once an infinitude of elements. The power series representation of a function, for instance, exhibits it as depending upon the infinite number of coefficients in such a representation; and

it is natural to consider how its properties depend upon and vary with those of these coefficients. A like problem arises in connection with the Fourier expansion and with many others. When one is embarked upon the study of functions of an infinite number of variables he cannot avoid the extension of his geometric conceptions so as to involve an infinite number of dimensions. The two things go together and afford mutual illumination. It is pleasing to see properties first developed for the finite case carried over to the infinite case, and our conception of the beauty of the system of truth is greatly enhanced when we see it in all the reach of its validity holding at once for all finite cases and for the infinite case. Naturally there are properties which distinguish and separate the finite from the infinite, so that some of them may be thought of as characteristic of the one and some of the other. We understand each of them better by seeing their analogies and differences, and thus we penetrate into a more satisfying realization of the nature and significance of the truth developed.

It is easy for one who has not meditated upon this matter to suppose that these are merely intellectual exercises with no other value than what is incident to the intellectual delight in them. But this is far from the truth. In fact, the phenomena of our environment have pressed these things upon us for a long time. Physical considerations brought us against the problem of an infinite number of variables long before we had any mathematical methods suitable for dealing with it. Let us take the intuitionally simple case of the motion of a uniform flexible string of given length and weight. This can be specified only by an infinitude of variable quantities, or coordinates, each depending on the time. In fact, physical phenomena usually depend in this way on an infinite number of variables. Lagrange's generalized coordinates furnish us one of the best and most remarkable means of studying motion—and it is to this that we try to reduce our interpretation of all physical phenomena. The Lagrange coordinates are finite in number for the simpler cases, but are infinite in number in the more general situations of nature.

For the development of the theory of functions of an infinite number of variables, both in the past and in the future, we have therefore the strongest sort of motives growing out of the beauty of the theory, the love of truth for its own sake, and the desire to understand better the environment in which we live. For this reason we may be sure that workers will be attracted to this subject and that it will have a great development, notwithstanding its inherent difficulty. We shall find after all

that much of it is elegant and many of its complexities will disappear in the light of the leading results which we shall attain.

Other progress in the same direction and under like impulses has been realized recently in the development of a theory of functions of curves and spaces. Again it is the physical considerations which have forced the problem upon our attention. This time it is the mathematical physicist who has formulated the new problem and laid the foundations of the consequent theory. If he seeks to study the potential due to an electric current in a fine wire—to take a simple case—it is clear that he has to do with a quantity which depends upon the shape of the wire and is varied by changes in the relative position of its parts. It turns out that there is so much of novelty connected with this new type of functions that some of the fundamental notions, such as that of derivative, for instance, are to be defined in a way not at first obvious. We are thus forced to a fresh analysis of the basic ideas of function theory in the light of a new body of material in which they are to find their use. This will certainly lead to a deeper understanding of these ideas and a more comprehensive view of the body of truth in which they are significant. To an unusual degree our curiosity is piqued to know the lay of the ground here and the direction in which the subject will develop. Already we are assured of its value owing to its many connections; and the concourse of all fundamental motives in a marked degree assures us of workers for the field and consequent progress of far-reaching character.

It is desirable for us to consider also the distribution of motive at certain periods of great mathematical advances in the more remote past. If we choose typical instances we shall be able to get some conception of the change of emphasis in motive and shall be able to see how the earlier is related to the more recent as put in evidence by the instances which we have just examined.

So far as mathematics was developed at all among the Egyptians it is clear that it was done in a crude way and essentially for its immediate practical uses. Such a spirit could not release a penetrating study and the consequent insight. It remained for the Greeks to rise to the higher motives associated with the love of truth and beauty and to lay the broad foundations of the science in the spirit which animates it to the present day. Due either to revulsion from the short-sighted vision of the Egyptians or (more likely) to the temperament of the Greeks themselves, the latter too largely ignored mathematical science in its aspect of usefulness in understanding the environment, giving their attention almost entirely to other matters.

The new point of view brought with it wonderful advances, but involved also certain elements to stand in the way of a continued and unbroken development.

The discovery of the existence of irrational magnitudes marks a significant event in the intellectual history of mankind. It was a matter of grave concern in the philosophical system of the Pythagoreans and for a long time they kept to themselves the awful and astonishing secret. In pursuing our study of these quantities (even down to the present day) we have been actuated primarily by the love of truth and beauty. No actual measurements of objects can reveal the presence of these irrational quantities, though it is easy to satisfy ourselves logically of their ideal existence. Only a part of our general motives are operative in their study.

The establishment of a vital and close connection between algebra and geometry was, in the mind of Descartes, a part of his search for a universal mathematical science which was to be only the prelude of a universal science of an all-embracing character. It grew out of a love of truth for its own sake. In geometry we seem generally to have emphasized this motive. It was so with the ancient Greeks, with Descartes, with the rise of modern pure geometrical methods, and with much of the recent development of the geometrical sciences. It is due to the inherent nature of this field of thought.

In the rise and development of the infinitesimal calculus we have a different state of affairs. Here there is scope for the vital activity of all three classes of motives and they have ever been conjointly in evidence. This is due in part to the extreme breadth of reach of the fundamental ideas of the calculus and in part to its peculiar fitness for the interpretation of motion, the basic element in terms of which we seek to interpret natural phenomena. That which grows out of the calculus and is intimately related to it is the most characteristic portion of modern mathematics and is primarily that which gives to it its large measure of importance. It is significant that it is also just the portion of modern mathematics in which our three classes of motives operate in the most nearly balanced proportion.

In the theory of functions of a complex variable, which is essentially an outgrowth and extension of the infinitesimal calculus, we have a field of truth which is rich in extent, in beauty, and in the quality of furnishing a means to interpret natural phenomena. In its initial rise, in its main features of interest, in the introduction of new ideas into it, and in its widening ramifications, we find constantly that activity which grows out of an intimate blending of the three general classes of motives.

It is the choice part of the most typical field of mathematical activity and illustrates beautifully the proper union and emphasis of motives.

The foregoing analysis of the work of a few mathematicians and the distribution of motive in the development of certain topics brings to notice three facts which are significant in this study: in the more recent mathematical work we have a definite tendency toward a more nearly equal emphasis on the three general classes of motives than is to be found in the earlier stages; this tendency is most marked in the more characteristic portions of modern mathematics; and this is true particularly in the case of the greater recent developments, especially of those in connection with broad general conceptions such as are present (for instance) in the theory of functions of an infinite number of variables and of functions of curves and spaces. This doubtless reveals a growing necessity incident to the greater complexity of the problems and the larger body of known truth on which the new discoveries must rest.

In our brief survey we have noticed how the greatest mathematical workers and the most important fields of mathematical thought have had an intimate connection with the interpretation of natural phenomena. England and France and Germany are the countries in which the most important and preeminent mathematical progress has been maintained for a long period of time coming up to the present. They have had workers actuated by all three of our fundamental classes of motives and a fairly well-balanced emphasis has been maintained among them. The cooperation of each with the others seems to have been essential to the progress effected. So far as mathematical research is concerned the English have leaned strongly towards its practical aspects, so much so in fact that they have suffered somewhat in their contributions; but in the last years there has been a growing tendency among them to correct the evil. In Germany all motives have operated strongly. Owing to the fact that the German university system teaches not only knowledge, but also research, no other country can show so many individual workers nor such a tendency to congregate into schools. Naturally, this is associated with much attention to minor problems and the doing of a large proportion of the drudgery incident to scientific progress. Fruitful ideas do not arise there as spontaneously as in some other countries, but no other people have shown a greater genius for developing the detail in connection with a leading fundamental idea once introduced. Mathematical progress in France during the past century has been of a most pleasing sort. All motives have worked in beau-

tiful cooperation and spontaneity of effort has led to the creation of many fundamental concepts. Here we see the best balance among the various motives and at the same time the most steady stream of progress. Each generation has been effective in a marvelous degree and their labors have not only enriched their own discoveries, but have also fructified mathematical thought throughout the world. Their experience and success seem to counsel the holding of a just balance among the three fundamental classes of motives.

So far, in America, we have realized progress in the pursuit of mathematical truth for truth's sake and in the pursuit of high esthetic satisfactions; but we have hardly realized anything in mathematics from the pursuit of means for interpreting and understanding our environment. This is strange in view of the distinctly practical turn of our people as a whole and suggests the opinion that we probably have an unused reservoir of strength which might become effective in the progress of applied mathematics. It is not to be supposed that a people of a practical turn of mind can produce mathematicians interested in the pursuit of ideal truth and of esthetic satisfactions and yet not have a source of strength for the development of the more practical aspects of the science. Some of our studies up to the present are adjacent to the field of applications; others are far removed from it; but very little of all that our mathematicians have done lies in the direction of a better understanding of natural phenomena.

We can not expect to maintain healthy progress by an unproportioned and one-sided development such as has characterized our work to date. Fortunately there is now a rising interest in America in applied mathematics. This should be developed and be guided into the best channels so that the work ultimately shall become of vital and far-reaching importance. By the nature of their previous work some of our mathematicians are definitely excluded from a leading part in this new development. They have devoted themselves to those fields of investigation which are far removed from the sciences of natural phenomena and therefore cannot turn their knowledge and experience to use in this direction. It is no cause for regret that this is so. In order to maintain as a people a balanced emphasis on motives we need to have individuals in which each fundamental class separately is dominant. But there are those whose labors have already led them to the borderland where pure and applied mathematics have a common boundary line. Some of these at least may step over into the adjacent field. For them to do so would seem to afford us our best and readiest

means of correcting the patent defect in our mathematical progress. We have already a young national tradition of high ideals in pure mathematics; let us as soon as possible realize the creation of a worthy tradition in applied mathematics.

A survey of the character of our contributions up to the present would probably suggest that our best point of entry is into the field of celestial mechanics, where in fact we have already done something, or into the theory of the partial differential equations of physics. Our previous labors in pure mathematics seem to have furnished us with tools suitable for use in either of these fields.

Every living science has two existences: one of them is objective, as in the body of scientific literature; the other is subjective, as in the minds of thoughtful persons and students of the particular science. The first is like a material body; the second is like the spirit. The first is enduring, like a stone or a mountain; the second is like a living organism, delicate in structure and highly susceptible to environment. Both of these existences are necessary to the progress of a science; indeed, necessary to its continued existence. The primary business of the researcher is to afford science its objective existence in the body of scientific literature. It is the business of the teacher to see that science has the second type of existence. Modern mathematics is now the heritage of a select few. We ought to make its great cultural elements a common property of cultivated people. But now it is notorious that they are unashamedly ignorant of this science. Nor is the fault to be laid entirely or even primarily at their door. We teach too much the mechanical aspect of mathematical reckoning and emphasize too little the great basic and fundamental notions which give to the science its vitality.

In each generation the most important labor that can be done is that expended in the creation or discovery of new truth. But this fact must not prevent our realization that the heritage of the past is to be preserved intact and transmitted to the future, not dead as in books, but living as in the minds of men and women. Not only must the line of progress be unbroken but many collateral branches must run out in all directions into the body of society, where scientific truth may bear fruit for the nourishment of mankind. A few persons will not suffice in this work of disseminating truth; many must be provided, if the truth is to be vital in the lives of our people generally.

As far as possible each individual should give his life to labors in which his spirit delights. This is necessary to the higher sort of intellectual achievement as well as to happiness.

Unless one rejoices in the realization of the general motives already treated there is no compelling reason why he should devote himself to mathematics; at most he can be only a weary plodder, whatever station he takes. Again, unless the matter of mathematical truth in its broader aspects exercises a deep influence over his meditations his labor in that field can not be particularly useful. To devote himself to it would be to waste his life, to spend in fruitless endeavor the energy which might be valuable if employed in more congenial pursuits. But the enthusiastic man or woman of merely moderate training has a place of importance in making mathematics live in the lives of the young and thence in the lives of the older. This is a labor in which one may take delight and through which one may project an influence into the future that shall work for permanent good.

A few can go further and render a more vital sort of service. A mere modicum of creative work of fair quality is of great value in the way of increasing the vitality of the teacher. The fact that he has created will illuminate the subject for him and give a different color to his teaching. His emphasis becomes better proportioned to the relative importance of the various topics and he is able to light his subject with the glow of personal fire and touch.

A significant measure of research is particularly important in the case of the teacher who prepares text-books for use in the more advanced undergraduate courses and for the first year of graduate work. It is unfortunate when embryo mathematicians are led over the basic portions of fundamental disciplines through the guidance of a dead exposition such as will usually emanate from one who has not himself advanced the subject in question or made use of its main ideas or results in some researches of his own. In America we stand now in danger of an increased number of these expositions lacking vitality. This is due to the concurrence of two or three causes. We have now a keen realization of the fact that there is among us a dearth of elementary expositions of the fundamental subjects. Our research men are engaged so zealously in their own investigations that they have usually not taken the time to prepare expository treatments; but this is an evil which seems to be in a state of progressive correction. In many of our institutions—especially among those which have lately aspired to positions of the higher importance—there is a peculiar (and sometimes an even dangerous) pressure upon the members of the faculty to produce publications of a professional sort. Some of the persons involved have not the training or the aptitude for research.

There is a danger that an increasing number of these will seek an outlet for their activity in the production of text-books. Already we have too much of this, so far as the more elementary texts are concerned. Let us hope that we shall be able to prevent the spread of the evil to the field next higher. One satisfactory way of offsetting this danger would be afforded by a greater willingness on the part of our research men to prepare introductory treatments, each one in his own field.

It is only when one is able to devote a large share of his energy to research and is successful in the creation or discovery of important new truth that he may rejoice in the fullest glow of delight through a realization in himself of all three general classes of motives. However important the work of instruction may be in itself and however far-reaching its stream of influence flowing in hidden ways in the minds of men and women, it can not be placed in the same category with that creative work which guides instructor and student alike and teaches generations what to think. He who discovers a fact or makes known a new law of nature or adds a novel beauty to truth in any way makes every one of us his debtor. How beautiful upon the highway are the feet of him who comes bringing in his hands the gift of a new truth to mankind!

No voice I raise to magnify the man
 That forms again the thought whose living fire
A palpitating spirit nobler than
 His own first warmed; his toils no zeal inspire.
 Of him, more worthy far, with joyful lyre
I sing, whose precious bit of novel truth,
 Revealed through labors long or hardships dire,
He lays before the feet of man. In sooth
Through him the aged world retains undying youth.

No tragic note inspires this quiet song.
 Abiding joy in truth is its deep spring,
And such delight as comes in labor long
 To him who learns by thinking everything
 His powers can clear of its dark covering.
When we the mind itself for truth entreat
 Or seek the hidden laws of happening,
By worthy labors make we conquests sweet—
Conquests of one without another's pained defeat.

No danger gives the keen Researcher zest;
 His languor no excitement can forestall;
No pain stirs deep emotion in his breast.
 He finds delight in truth or large or small,
 In those whom interest or pleasure call
Our ambient environment to scan,
 In fresh control of nature's forces all

Through better understanding of her plan,
In glimpses new into the growing soul of man.

How grew the keen Researcher? How? He grew
In common ways of life to manhood's state
And felt with gladness strength to strength accrue
As each new-found experience lent its weight
To serve the old or novel thought create.
The constant play of THINGS upon his soul
Remade in him whatever was innate
And moved him with the sense of deep control
Wrought out in him by forces centering from the WHOLE.

Into his inner thought these forces come;
They bring the flavor of the world outside;
And in his inmost heart, no longer dumb,
They speak in gracious accents to confide
Their meaning, blessing him as yet untried.
Not long with him alone a truth remains;
But, redirected, moves from this new guide,
And as it leaves a greater strength attains,
But holds new character the chief of all its gains.

Thus the Researcher early learned the truth
Which entered more and more into his thought
As manhood's state in time succeeded youth
And years grew longer decades while he brought
All power of mind to bear on what he sought:
Whatever comes beneath the busy hand
Of man, on which with power it has wrought,
Goes forth transformed in newness to expand
To what it was not, gladly doing his command.

The life of man is wrought of various parts
Which hold together in complexity;
No hand is skilled in divers proper arts
To draw the line of truth upon the sea
Where waves of change surge forth in full degree.
A separated part must one procure
Where change is not too vast for him to see
Its secret, if he makes a conquest sure
Which through the ages of the future shall endure.

'Tis this the watchful, keen Researcher sees:
It guides him to a bounded field of thought;
It teaches him the need of new degrees
Of power by which his conquests may be brought
To bear on widest realms with blessing fraught.
A zeal arises in his inmost heart,
A consecration by deep purpose wrought
Absorbs his strength, his life he sets apart
To bless mankind by streams of truth which from him start.

INSECTS WHICH ATTRACT PUBLIC ATTENTION

By Professor HARRY B. WEISS

NEW JERSEY STATE DEPARTMENT OF AGRICULTURE

CERTAIN species of insects are more or less continually attracting the attention of people and, while the following remarks apply particularly to the New Jersey public, there is no reason why they should not hold good for many other eastern states where conditions are somewhat similar. The entomologist of a state or experiment station is perhaps more likely to be familiar with such insects than any other agency, inasmuch as one of the duties of his position is to furnish insect information upon request and by reason of his official position, a large percentage of such requests naturally fall into his hands.

In view of the fact that 10,530 species of insects have been recorded from New Jersey, it might appear that out of this large number three or four hundred would attract attention annually, but such is not the case, as the following condensed tables will show. These tables have been compiled from the reports of the entomologist of the New Jersey Agricultural Experiment Stations,[1] for the five years 1913 to 1917, containing lists of the insects about which information was requested during the year. Such lists reflect public interest in entomology and should be fairly accurate for the purpose. The species mentioned in such correspondence naturally fall in the following groups—those injurious in the household and to stored products, those injurious or annoying to vertebrates, those injurious to vegetation and predatory species. A few additional groups could be added, but for the sake of simplicity and on account of the slight public interest in them these have been placed together in the miscellaneous columns of the tables. These tables also give the names of the orders to which the insects belong, the total number of species involved and the number of inquiries received.

It will be seen that species in orders such as the Thysanura, Thysanoptera, Odonata, Isoptera and Neuroptera attract very little attention, due to the fact that such groups contain only a

[1] Headlee, T. J., Repts. Dept. Ent. N. J. Ag. Exp. Sta., 1913–1917.

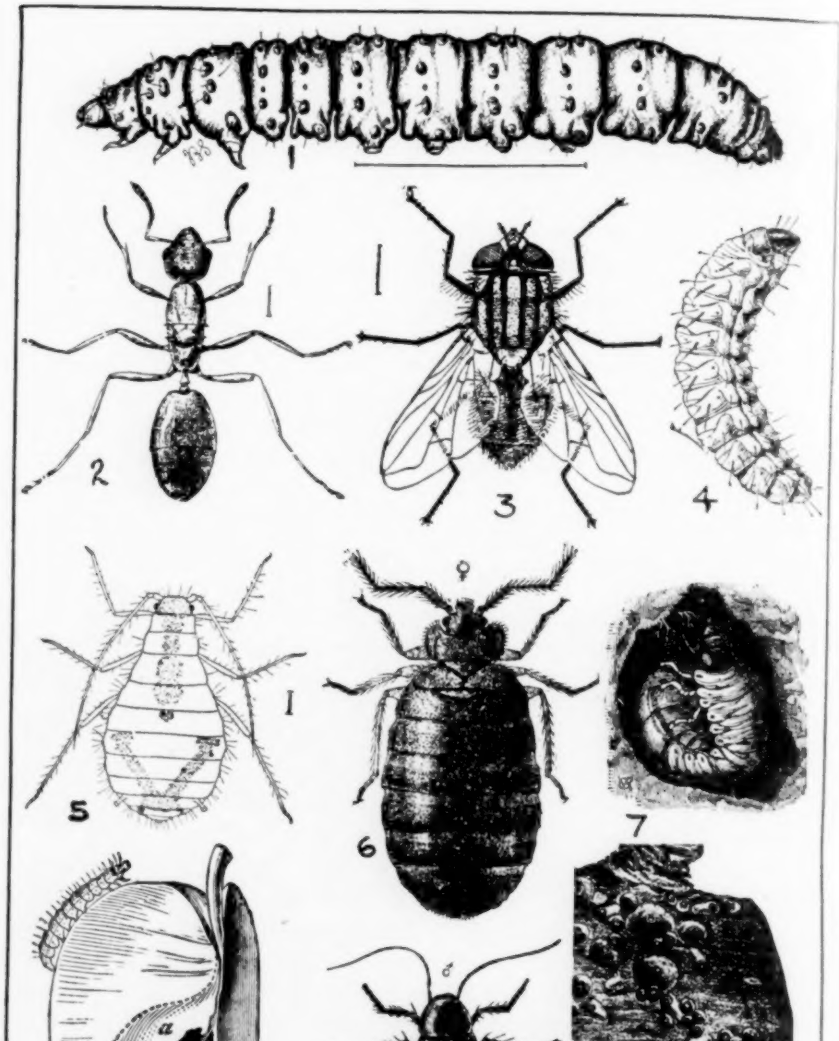
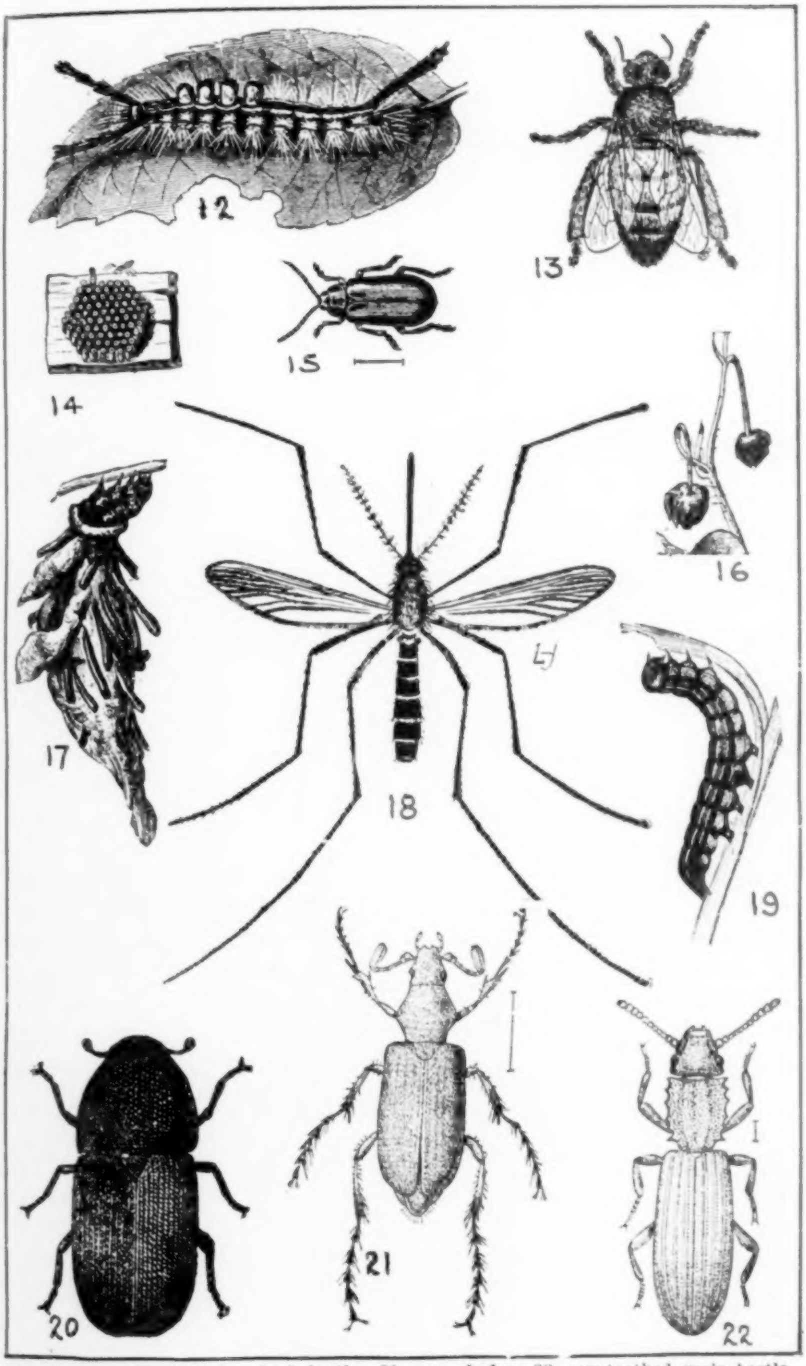


FIG. 1, peach borer larva; 2, little red house ant; 3, house fly; 4, plum curculio larva; 5, a plant louse; 6, bed bug; 7, white grub; 8, codling moth and larva and injury to apple; 9, roach; 10, San Jose scales; II, cabbage maggot; 12, tussock moth caterpillar; 13, worker honey bee; 14, egg mass of wheel bug; 15, elm leaf-beetle; 16, strawberry buds cut by weevil; 17, bag worm; 18, house mosquito; 19,



army worm; 20, fruit tree bark beetle; 21, rose chafer; 22, saw-toothed grain beetle. (Figs. 1, 5, 18, after Smith; Fig. 11, after Smith and Dickerson; 13, after Carr; 3, after Howard; 20, after Forbes; 10, from Bull. Virginia Exp. Sta.; 7, 19, 12, after Riley; remaining figures from Bur. Ent. U. S. Dept. Agric.)

TABLE I. 1913

Order	Total No. Inquiries	No. Species Involved	Injur. to Household and Stored Products	Injur. to Vegetation	Injur. to Verte-brates	Predatory Species	Miscell. Species
Thysanura	2	1	1				
Isoptera	2	1	1				
Neuroptera	1	1					
Thysanoptera	2	2		2			
Homoptera	158	41		41			
Hemiptera	12	5		3	1	1	
Orthoptera	7	5	1	4			
Coleoptera	84	35	7	26		2	
Lepidoptera	71	33	2	31			
Hymenoptera	16	9	1	7		1	
Siphonaptera	1	1			1		
Diptera	54	12	2	7	2		1
Total	410	146	15	121	4	4	1

TABLE II. 1914

Order	Total No. Inquiries	No. Species Involved	Injur. to Household and Stored Products	Injur. to Vegetation	Injur. to Verte-brates	Predatory Species	Miscell. Species
Thysanura	1	1	1				
Thysanoptera	1	1		1			
Homoptera	106	33		33			
Hemiptera	11	8		6		1	1
Orthoptera	8	8	3	4		1	
Coleoptera	101	49	2	44		3	
Lepidoptera	106	38		38			
Hymenoptera	16	13	2	6		2	3
Siphonaptera	3	1			1		
Diptera	27	14	2	9	3		
Total	380	166	10	141	4	7	4

TABLE III. 1915

Order	Total No. Inquiries	No. Species Involved	Injur. to Household and Stored Products	Injur. to Vegetation	Injur. to Verte-brates	Predatory Species	Miscell. Species
Isoptera	2	1	1				
Odonata	1	1					1
Thysanoptera	7	2		2			
Homoptera	125	39		39			
Hemiptera	10	7		4	1	2	
Orthoptera	14	5	2	2		1	
Coleoptera	92	36	7	28		1	
Lepidoptera	120	36	1	35			
Hymenoptera	36	11	1	6		1	3
Siphonaptera	3	1			1		
Diptera	65	19	2	12	4		1
Total	475	158	14	128	6	5	5

TABLE IV. 1916

Order	Total No. Inquiries	No. Species Involved	Injuries to Household and Stored Products	Injur. to Vegetation	Injur. to Vertebrates	Predatory Species	Miscell. Species
Homoptera	79	31		31			
Hemiptera	7	4		3	1		
Orthoptera	4	4	2	2			
Coleoptera	80	32	6	26			
Lepidoptera	75	32	1	31			
Hymenoptera	26	11	1	7		1	2
Siphonaptera	4	2			2		
Diptera	54	17	1	14	2		
Total	329	133	11	114	5	1	2

TABLE V. 1917

Order	Total No. Inquiries	No. Species Involved	Injur. to Household and Stored Products	Injur. to Vegetation	Injur. to Vertebrates	Predatory Species	Miscell. Species
Thysanura	1	1	1				
Thysanoptera	1	1		1			
Homoptera	190	36		36			
Hemiptera	10	6		4	1	1	
Orthoptera	17	8	1	5		2	
Coleoptera	110	33	5	28			
Lepidoptera	150	48	1	47			
Hymenoptera	40	11	3	3		2	3
Siphonaptera	6	2			2		
Diptera	67	21	1	16	2		2
Total	592	167	12	140	5	5	5

comparatively small percentage of the total number of species in all orders and because of the relatively few injurious species in them. Most of the species which attract the attention of the people are found in such orders as the Homoptera, Coleoptera, Lepidoptera, Diptera and Hymenoptera, with the first three leading. These three groups include a large percentage of forms which feed upon vegetation, while in the Diptera and Hymenoptera the percentage of injurious species is smaller.

The striking thing shown in all of the tables is the small number of species involved, considering the number of injurious forms in each group. Thus of the Homoptera, with a total number of recorded species in New Jersey of 507, with all of them feeders upon vegetation, only from 31 to 46 species attracted attention. The number involved in the Lepidoptera varied from 32 to 48 and this order contains at least 2,000 species, which are feeders on vegetation in a recorded number of 2,120 in New Jersey. Of the Coleoptera, with its 3,000

recorded species, 1,200 of which are injurious to vegetation, the number attracting attention varied from 32 to 49. The same thing is true for the remaining orders.

TABLE VI

	Total No. Inquiries	No. Species Involved	Injur. to Household and Stored Products	Injur. to Vegetation	Injur. to Vertebrates	Predatory Species	Miscell. Species
1913	410	146	15	121	4	4	1
1914	380	166	10	141	4	7	4
1915	475	158	14	128	6	5	5
1916	329	133	11	114	5	1	2
1917	592	167	12	140	5	5	5
5-yr. average . . .	437	154	12	129	5	4	3

Table VI. is a partly summarized account of the preceding tables and shows the five-year averages. Thus from a five-year average of 437 inquiries only 154 species were involved, 129 of which attracted attention because they were injuring vegetation, five because of their annoyance or injury to vertebrates and twelve because of their trouble in the household or to stored products. The average number of four species in the predatory column probably attracted attention because they were thought to be injurious and the same is true of most of the three species in the miscellaneous column, these representing wasps, bees and parasitic forms in both Hymenoptera and Diptera.

The relationship between the number of inquiries and the number of species involved for the five-year period is shown in Chart I. The "species involved" curve shows very little variation, while the "inquiry" curve is very irregular. This is due to the fact that an outbreak of a certain species or several species will add materially to the number of inquiries but not increase the number of species very much.

Among the species involved in each group, a small number attracts most of the attention. In the Homoptera they are plant lice and scale insects, the plant lice being those infesting orchard trees and garden plants, the scales being those found commonly on fruit, forest and ornamental trees. In the Hemiptera, the bed bug and squash bug appear to be popular, with several species of leaf bugs holding second place. The eggs of the wheel bug (*Arilus cristatus*) and one or more species of assassin bugs, which also are predatory, usually receive some slight attention, due to the fact that they are thought to be injurious. More species are involved in the Coleoptera, but

the public favorites are white grubs, wire-worms, plum curculio, bean weevil, potato beetle, potato flea beetle, elm leaf-beetle, rose chafer, strawberry weevil, asparagus beetle and fruit bark beetle. Similar conditions exist in the Lepidoptera, the species attracting most attention being the corn-ear worm, apple tree tent-caterpillar, peach borer, cut worms, tussock moth, bag-worms, codling moth, cabbage worm, army worm

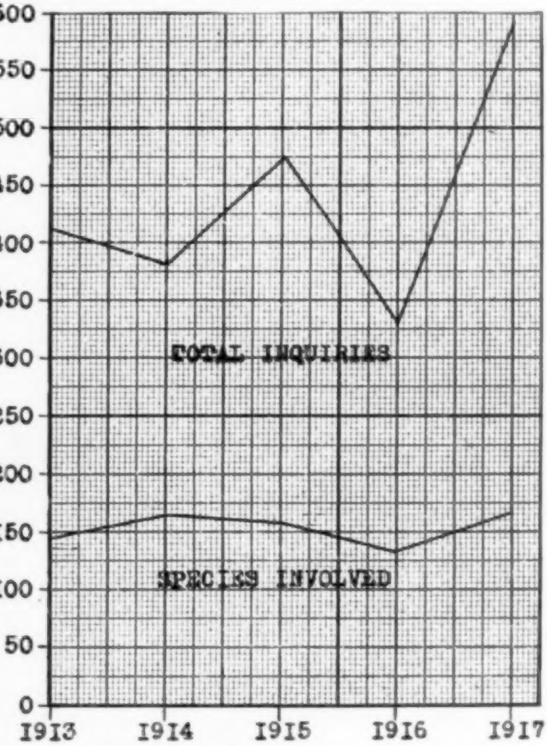


CHART I.

and squash borer. In both Hymenoptera and Diptera a smaller number of species is involved. In the former order, ants, saw flies and bees are the most important from a public viewpoint, while in the latter we have the house fly, mosquitoes, Hessian fly and cabbage and onion maggots occupying first place. On the accompanying plates may be found illustrations of some of the species which are more or less constantly in the public eye. To the entomologist they represent well-known pests, but the public is always demanding information about them.

Briefly summarizing, the insects which ordinarily attract public attention are those which annoy or injure man or those

which destroy or injure his personal belongings, crops and live stock. Certain supposedly harmless species and certain species destructive in some areas but not in others have attracted widespread attention, but only by reason of the advertising which they received. In such cases public attention was directed to them and not attracted by them.

The average number of inquiries received during a year compared with the total population (2,800,000) of a state like New Jersey appears to be exceptionally small, and to some might indicate little public interest in insects. This, however, is not unusual when one considers the varied industries in the state and the fact that "75 per cent. of all the people are found in communities of over 2,500, occupying less than six per cent. of the whole area."[2] Except for such creatures as flies, mosquitoes, certain household and shade-tree pests, the city and town dweller is not likely to have his attention attracted to insects. In New Jersey, considerable public interest is centered around a few rather than many species. As outbreaks of pests are simply responses to environments, so public interest in insects is a response at least in part to environment, whether it be natural or artificial.

[2] Ann. Rept. N. J. Dept. Conservation and Development, 1917.

PROFESSOR JOHN MERLE COULTER

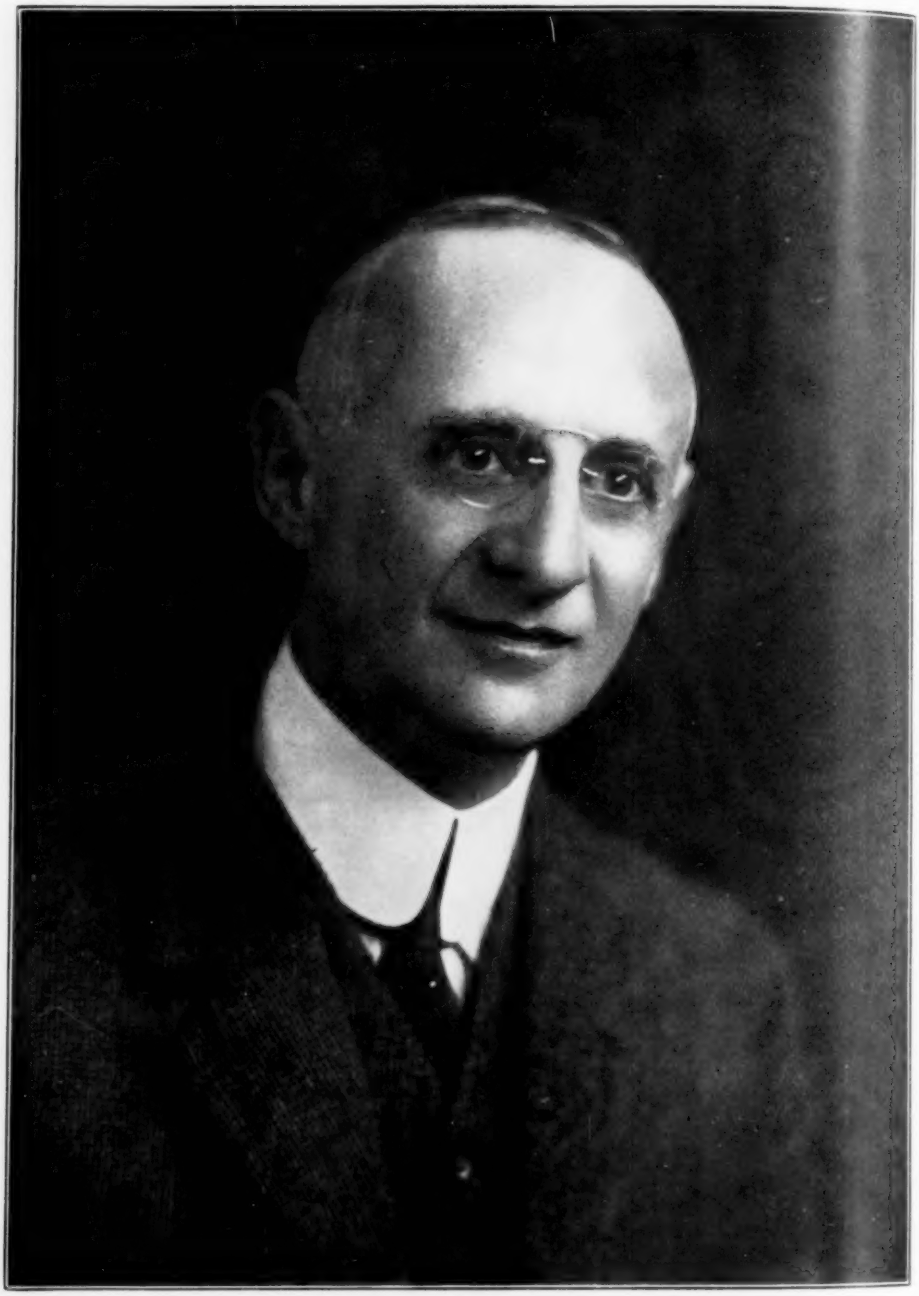
Head of the Department of Botany of the University of Chicago, Retiring President of the American Association for the Advancement of Science.

THE PROGRESS OF SCIENCE

THE WORK OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE Baltimore meeting of the American Association for the Advancement of Science and the national scientific societies affiliated with it was unusually and unexpectedly successful. Owing to war conditions, the place of meeting had been changed from Boston to the neighborhood of Washington, and it was planned to hold a small meeting devoted primarily to war work. The signing of the armistice altered the situation, and the meetings of the association and of those affiliated societies which had not postponed their meetings were largely attended and full of interest.

The association was fortunate in meeting at Johns Hopkins University, the original home of academic research in the United States. Professor Theodore W. Richards, director of the Wolcott Gibbs Memorial Laboratory of Chemistry at Harvard University, the retiring president, Professor John M. Coulter, head of the department of botany at the University of Chicago, the president of the meeting, and Dr. Simon Flexner, director of the laboratories of the Rockefeller Institute for Medical Research, the president-



Dr. Simon Flexner

Director of the Laboratories of the Rockefeller Institute for Medical Research.
President of the American Association for the Advancement of Science.

elect, are admirable examples, in their own work and on account of the sciences in which they lead, of the contributions of scientific research to the welfare of the nation.

To chemistry we owe in large measure the successful conduct of the war and the maintenance of our manufactures; to botany our agricultural products which have saved the world from starvation; to pathology the low death rate from disease in the army. If chemical research and its applications are given what they need, the material primacy of the nation is assured; if botany and related sciences are adequately supported, the productivity of our farms and gardens can be doubled; if pathology has more men of the type of Dr. Flexner, 5,000,000 deaths such as have been caused by the epidemic of influenza can not recur.

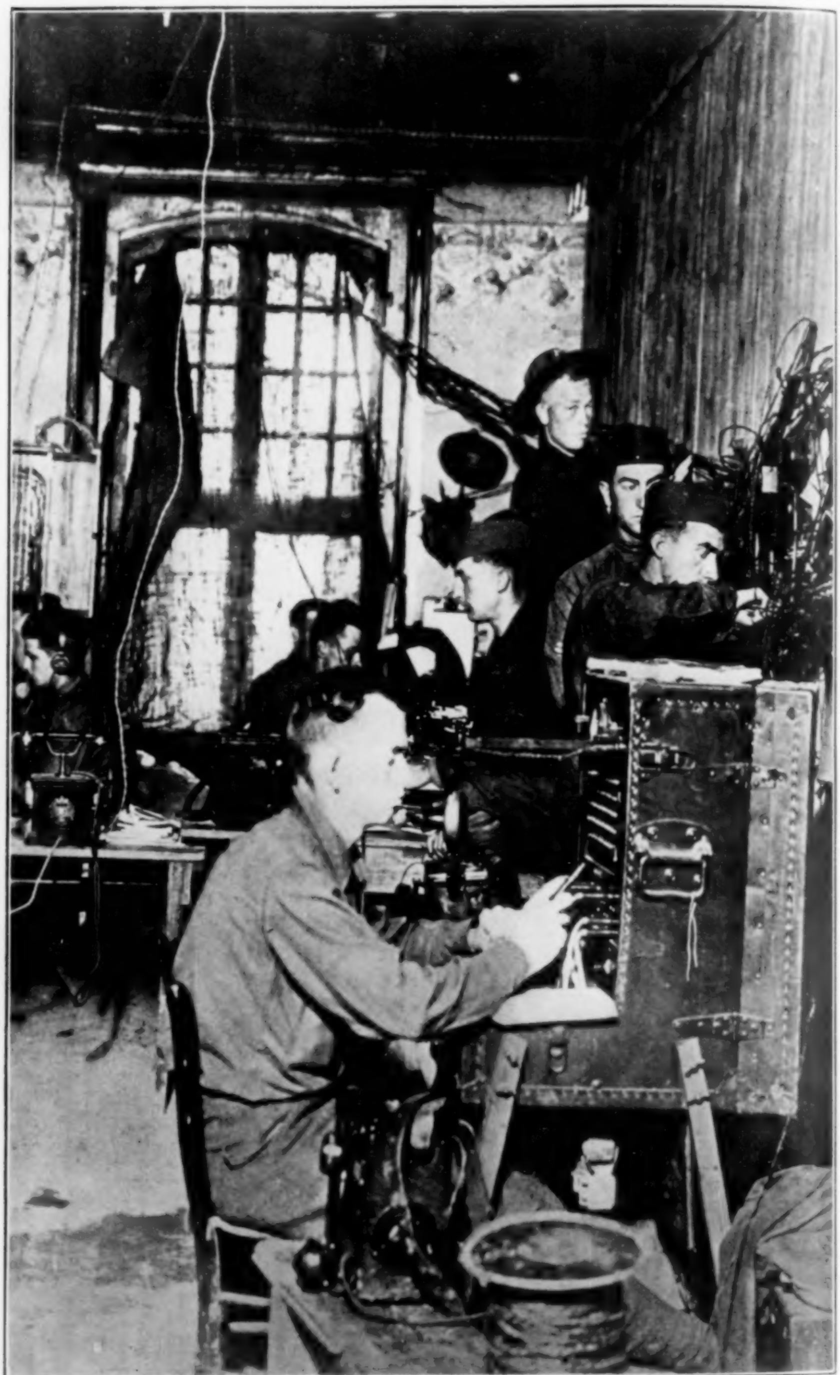
It was realized by all present at the Baltimore meeting that science and the scientific men of the country were leading factors in bringing the war to a quick and favorable conclusion. The applications of science have enabled the country to amass the immense wealth which could be devoted to the purposes of the nation; our scientific men were able to meet on terms of equal performance those of every other nation. In like manner it was agreed that science and scientific workers have a great part to play in the reconstruction period in which we are entering. The whole future of the nation rests on the proper development and distribution of our resources in natural wealth and in men. We must now decide to lead in scientific research and in the applications of science for the welfare of the people of the country.

Science, education, democracy and organization are the four corner stones on which our civilization is based. Science may properly be placed first, for the applications of science have made it possible to provide education and equality of opportunity for all. The debt of education and democracy to science for its past service, their dependence on science for their further progress, are so great that no support given to science can repay their past obligation or sufficiently strengthen its hands for its future work.

There is probably no other association in the world that represents so completely as the American Association for the Advancement of Science, the four fundamental bases of modern civilization, science, education, democracy and organization. Its object is the advancement and the diffusion of science, perhaps the most important of all educational work. It has a special section devoted to the scientific investigation of educational problems. Not only is its work essential for democracy, but it is itself a democratic institution. It welcomes to fellowship all scientific workers and to membership all those interested in science. Its council, on which all the national scientific societies are represented is a democratically elected body that can speak and legislate for the scientific men and scientific work of the country. The association now has some 14,000 names on its membership list. with the affiliated societies, some 25,000, or 100,000 if physicians and engineers represented on the council are included.

This great body should be used effectively for the advancement and diffusion of science. In a democracy we must depend on the knowledge and good will of the people for the opportunity to do the work that is of such surpassing value for them. We must make the scientific career so attractive that able men will be drawn to it, and we must then give them the best possible opportunity to do their work.

This requires education and or-



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An American Field Signal Battalion Telephone Switchboard in Operation on the St. Mihiel Salient. Some of the equipment had been captured from the Germans which is indicated by the German Eagle, stamped on one of the telephones in the background.

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WIRELESS SET MOUNTED ON A TRUCK OF A FIELD SIGNAL BATTALION IN FRANCE.

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MEMBERS OF A FIELD SIGNAL BATTALION SIGNALLING BY WIRELESS TO AEROPLANES.

ganization. Every scientific worker and all those who appreciate the fundamental place of science in national welfare should unite to do their part through our scientific organizations. They should be members, and active members, of the special society in their field, of their local society or academy, and of the American Association for the Advancement of Science.

The next meeting of the American Association and its affiliated societies will be held in St. Louis, beginning on December 29, 1919. The occasion should be taken to strengthen the association and its work in the central states, which have in recent years assumed such leadership in scientific research. We may be sure that the scientific men of Washington University and the City of St. Louis will do their part. It would be well if the meetings might be celebrated by the affiliation with the association of the strong state and city academies of the Central States and the organization of a central branch of the association on the lines that have proved so successful on the Pacific Coast.

THE INTERALLIED CONFERENCE ON INTERNATIONAL SCIENTIFIC ORGANIZATION

At a meeting of representatives of scientific academies of the allied countries and the United States, held in London on the invitation of the Royal Society in October, a committee of enquiry was formed, which met in Paris at the end of November. The delegates in attendance were: *Belgium*—MM. Lecointe, Massart, de la Vallée Poussin; *Brazil*—M. de Carvalho; *France*—MM. Painlevé, Guignard, E. Picard, A. Lacroix, Lippman, E. Perrier, Roux, Haller, Bigourdan, Baillaud, Lallemand, Moureu, Flahault; *Italy*—Sen. V. Volterra, Professors Reina, Nasini, Ricco, Fantoli; *Japan*—Professors Tanakadate and Sakurai; *Poland*—M. L. Mickiewicz; *Rumania*—MM. Soutzo, Hurmuzeco, Mrazzee, Marinesco; *Serbia*—MM. Zujovio, Petrovitch, Jopovitch; *United Kingdom*—Professor Schuster, Mr. J. H. Jeans, Sir Frank Dyson, Sir E. Sharpey Schafer, Professors Frankland, Sherrington, and Starling, Col. Lyons, Dr. Knott; *United States of America*—Professor Bumstead, Col. Carty, Drs. Durand, Flexner, Hale, Noyes.

An International Research Council was formed, and a committee of five was elected consisting of MM. Picard (chairman), Volterra, Lecointe, Hale, and Schuster. The seat of the bureau is to be in London. It is understood that the organization and arrangements are provisional, to be confirmed later by the academies and societies which enter the movement.

One of the organizations planned is an International Geophysical Union, which is intended to be controlled by an international committee consisting of representatives of international councils and of delegates appointed by the governments. The number of delegates is to be proportional to the size of the nation, as is the contribution by each. Only those nations that have been at war with Germany may enter the union, but arrangements may later be made for the admission of neutral nations.

SCIENTIFIC ITEMS

We record with regret the death of Wallace Clement Sabine, professor of physics at Harvard University and formerly dean of the Lawrence Scientific School; of Rossitier Worthington Raymond, the well-known mining engineer, and of Robert John Pocock, director of the Nizamiah Observatory, Hyderabad.